The ARL 'Black Box' Flight Recorder – Invention and Memory

Jeremy Sear

14567

Length of Thesis
14,000 words

A thesis submitted in fulfilment of the requirements for the degree
of Bachelor of Arts (Honours).

Department of History
Faculty of Arts
The University of Melbourne

October, 2001

Acknowledgements

I would like to thank the following spectacularly fantastic people:

- My Thesis Supervisor, Mr Don Garden, for his invaluable assistance and rather astonishing patience throughout the year.
- All the kind people who have offered their time and reminiscences of events which took place forty years in the past – in particular Dr David Warren, Mr Ken Fraser, Dr Bill Schofield, Mr Peter Langford, Mr Frank Yeend, Mr Macarthur Job, Mrs Edna and Ms Dinah Boswell, Mrs Marie Ferrari, Ms Morna Kenworthy of the AFAP and Ms Edwina Burgess at AMRL.
- My friends and family who have provided invaluable advice and assistance in the final preparation of this Thesis – in particular, David and Edwina Sear, Leif Cooper and Briony Eves, and all those who made helpful comments.
- Melanie, above all, for advice, enthusiasm and extraordinary support, throughout the entire preparation of this thesis.

The ARL "Black Box" Flight Recorder – Invention and Memory.

Contents

Introduction

The first items investigators look for after an aircraft crash are the cockpit voice and flight data recorders, more commonly known by their combined name - the 'black box'. In the recent incidents in New York and Washington DC, the evidence provided by the cockpit voice recorders (CVRs) was keenly sought in order to determine the identity of the hijackers. Over the thirty years 'black boxes' have been in service, they have provided insight which has undoubtedly saved the lives of countless air travellers.

The CVR was invented in 1954 by an Australian scientist, Dr David Warren, and subsequently developed by the Aeronautical Research Laboratories (ARL – now the Aeronautical and Maritime Research Laboratory, AMRL) in Melbourne at which he worked. It was, for many years, completely ignored. Although the ARL technology was developed into flight recorders used in airlines around the world, and although Australia was in 1963 the first country to make flight recorders mandatory, the ARL recorders were never used by Australian airlines. Australian industry never profited from the idea.

Warren himself was only brought back from obscurity by an article in The Age in 1985 by Geoff Maslen entitled 'The Box: Australian genius lost out to bureaucratic myopia'.[1] This set the tone for all the subsequent pieces in newspapers, 'popular' magazines (such as *Time Magazine*)[2], and various 'educational' television programs (such as Channel 9's *Our Century* series and a documentary produced for the Smithsonian Institute in the US).[3]

Warren and the ARL could not get manufacturers interested in the idea unless the then Department of Civil Aviation (DCA) proposed making it a requirement; and DCA was not prepared to take that risk until the technology could be shown to work. For this decision DCA has been demonised with hindsight, in the cause of cementing an Australian claim to fame. The often-observed Australian dislike of authority manifests in easy condemnation of unnamed public servants. In both *Australian Aviation* and the *Herald Sun*, aviation journalist Macarthur Job accused the DCA of having made a 'serious misjudgement' which 'embarrassed' officials.[4] The *Herald Sun* took the unsurprising angle that 'patriotic pride is not enough, not when smart foreign corporations can reap enormous profits from the struggles of our inventors' and declared that 'Australia must never again turn its back on people such as David Warren.'[5] When Dr Warren was interviewed on ABC radio in February 2001 by Jon Faine and Andrew Bolt, he found himself having to restrain the journalists in their eagerness to denounce the authorities of the time. With a tinge of self-righteousness Bolt demanded – 'didn't no-one [sic] in Australia have the nous to think, well look, here we've got the transport mode of the future… we're going to get in on this?' Warren had to explain the context – 'We didn't have the accidents in Australia… I don't blame them [DCA]. Because if something hasn't happened for 10 years you're quite right to say it's not worth worrying about.'[6]

The populist discourse represented in the majority of the literature is strongly nationalistic, and essentially unconcerned with the hazier aspects of the story. Errors are prevalent, and remain uncorrected by proper research. Non-ARL perspectives are ignored, and only a single, simplistic answer offered as to why Warren's invention was ignored by Australia: 'bureaucratic incompetence'. This thesis will explain why this easy answer is unsatisfactory, although it has been, to date, the only one proffered.

---

[1] Geoff Maslen, 'The Box: Australian genius lost out to bureaucratic myopia', *The Saturday Extra, The Age*, Saturday, 25 May, 1985, p 1. Maslen had been present at a lecture up at the State Library that Warren gave on his retirement in 1985, and was inspired to write this two-page article for which, Warren recalls, he received an award for 'presenting a scientific topic to the public.'

[2] Macarthur Job, 'David Warren: With an ingenious invention, he helped make air travel safer for millions of people', TIME Magazine, October 25, 1999, p 108.

[3] 'Flight Memory "Black Box" Recorder, Smithsonian Institute, Episode 15, Discovery Channel, 5 mins, video cassette, held by the AMRL, Department of Defence, Defence Science and Technology Organisation, VT No. 3109, 1992. Broadcast in Australia as 'Invention Episode 5' on the Foxtel Discovery Cable Channel 6, February 25, 1997.

[4] Macarthur Job, 'Long Overdue Recognition for "Black Box" Pioneer', *Australian Aviation*, March 2001, p 42, and Macarthur Job, 'Inventor honoured at last', *Sunday Herald Sun*, November 19, 2000, p 11..

[5] 'Smart society', *Herald Sun*, Monday, November 20, 2000, p 18.

[6] 'Morning with Jon Faine,' ABC 774 3LO Radio Station, February 20, 2001, 11:42 AM. Transcript provided by Media Monitors.

The persecution theory of Warren's struggle to get his idea developed has been extremely tenacious for two reasons. Firstly, because it is a perspective which fits Australian views of a legendarily complacent government bureaucracy, and secondly, because there is public empathy for the 'lone hero' paradigm. Warren did indeed face unnecessary hurdles, due to the structure of the system that required considerable perseverance to overcome. However, in none of the 'black box' historiography have the difficulties been placed in context. Warren found himself in the Catch-22 situation of waiting for two departments, neither of which would move until the other did, because what was required was the specific responsibility of neither. This thesis endeavours to provide a more balanced historical account of the period, by exploring the perspectives of the DCA, the airlines, and the pilots. To simply portray these groups as unimaginative or cowardly villains, as they have been throughout the literature, is poor history.

The sole academic contribution to the literature was Basil Walby's 1993 Master of Science thesis at the University of Melbourne,[7] contrasting the troubled development of Warren's invention with that of the atomic absorption spectrophotometer (AAS) invented in 1953 by Alan Walsh of the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Walby had access to the correspondence and other documents identified in the ARL files as 'C2/78 Flight Memory Project' and covering the period June 1958 to May 1968. (These have since been collated and augmented by Warren and the only surviving member of the ARL team that worked on the device, Ken Fraser.) Walby defended his use of this record on the grounds that 'although many of the individual contributions may be biased, the over-all effect will be relatively unbiased as any extreme views of the protagonists tend to cancel each other out as the tale unfolds.'[8]

This thesis also depends largely on the ARL documents, combined with unexplored testimony of surviving participants. I have also had access to previously unreleased collections, particularly private papers of the ARL team, and correspondence held by the Australian Federation of Airline Pilots (AFAP). Further, in addition to the testimony of Warren and Fraser, who have been interviewed on the subject by many others, I have also been able to talk with surviving figures from the DCA and the airlines of the time, as well as the families of the ARL team.

Unfortunately, as Walby noted, one of the chief difficulties in researching the ARL Flight Memory project is that 'there is no strong continuity in written records of the work on the CVR that lead back to the invention of the instrument at ARL in Melbourne.'[9] It is clear that Warren's 1954 proposal of a CVR is the first; there is no dispute that the specific invention described was his. However, many of the documents which would be most revelatory, such as minutes of the Commonwealth Advisory Aeronautical Research Council (CAARC) meetings that first discussed and dismissed Warren's proposal, no longer exist. Private companies, like Davall, the UK manufacturers who developed the ARL design into the 'Red Egg' recorder, no longer exist (Davall is now Vinten) and do not have archive material available. This means that the historian must rely to a great extent on oral testimony, with all the dangers that implies.

The debate raised by past portrayal of the DCA involvement with the ARL research is a singular example of this. In 'The Knife Edge: Debates about Memory and History', Paula Hamilton notes that participants 'argue over what happened and what interpretation to place on the experience, which is usually negotiated through the collective process of remembering.'[10] When people's memories of events are contrasted and differences found, 'struggles over the possession and interpretation of memories are deep, frequent and bitter.'[11] In the case of the 'black box', however, the frustration felt by the DCA people – 'no-one on the ARL side of the problem will listen'[12] – since Maslen's article (and probably matching the frustration felt by the ARL people up until Maslen's article), has been matched by a desire from both sides to 'mend bridges'. Warren and Fraser are careful not to offend by making any claims they feel unable to clearly support, and are wary of relating impressions other than 'hard facts.' There is an unwillingness to defend memories once challenged – interviewees prefer to make the caveat that their age and the intervening forty years render their recollections

---

[7] Basil J. Walby, *Two Australian Black Boxes: Institutions and Innovation*, Thesis submitted as part completion of an M.Sc. Science and Society, University of Melbourne, 1993.

[8] Ibid, p 13.

[9] Ibid, p 31.

[10] Paula Hamilton, 'The Knife Edge: Debates about Memory and History', in Kate Darian-Smith and Paula Hamilton, eds, *Memory and History in Twentieth-Century Australia*, Oxford University Press, Melbourne, 1994, pp 9-32, p 15.

[11] David Thelen, 'Introduction: Memory and American History', in David Thelen, ed, *Memory and American History*, Indiana University Press, Bloomington, 1990, p xvi.

[12] Peter Langford, email, September 28, 2001.

approximate. This makes it very difficult to elaborate the fine details necessary to definitively complete the documentary record.

Walby's thesis is a clear account of the different experiences of Walsh and Warren, the former having been always clearly identified with his invention, and the latter having been largely ignored outside the ARL and Davall until Maslen's article. It does not, however, complete the narrative, which is outside its scope. It devotes more than half of its length to Walsh's invention, perhaps because that documentary record was more accessible. It ignores the ARL team, whose advanced technology developed into an actual commercial recorder. The popular literature does likewise, perhaps both because the team's contribution was technical and not easily explained, and because it detracts from the more attractive 'lone hero against the doubters' legend.

Surprisingly, the academic literature relating to science and technology investment in Australia is thin to non-existent. Primary documents relating to contemporary critiques of government policy are easily accessible; but little historical analysis exists. The Australian Science and Technology Heritage Centre is currently attempting to collate biographical information on Australian inventors, but there are no suitable relevant secondary sources on the subject to provide a context into which to place this research.

This thesis argues that a properly-researched study, which has never been produced solely on the subject of Warren's 'black box', is an important contribution to genuine national history. It argues that academic inquiry can be usefully undertaken in fields which have hitherto been ignored – even in the absence of established secondary dialogue and discourse, and even if this requires the elaboration of a new historical narrative.

It therefore examines the issues of memory and neglected history through a thorough exploration of the narrative of the development of the 'black box'. It completes aspects of the record which have generally been ignored, explores the weaknesses in 'nationalist history', and attempts to resolve the contentious issue of why the 'ARL Flight Memory' has come to represent the perennial thwarting of innovative Australian science and technology.

Chapter One – Dr Warren's Idea

> Invention really is one percent inspiration, ninety-nine percent perspiration.
> David Warren, 2001, parodying Thomas Alva Edison's famous observation on genius.[13]

This first chapter explores the question of memory and history through the narrative of Warren's development of the idea of a cockpit voice and flight data recorder. Warren's recollections are complemented by those of representatives of organisations which have traditionally been blamed for not enthusiastically taking up the idea. It investigates the issue of judging people according to the unreasonable standards of hindsight. Finally, it explores the historical context – ignored by the literature to date – of the initial stages of the recorder's development.

The reception within Australia of Dr Warren's idea for a combined cockpit voice/flight data recorder was a direct result of the state in which the country found itself after the Second World War: an isolated producer of raw materials. Predominantly British in population and culture, the country had been shocked when Prime Minister Curtin turned to America for assistance after the Royal Navy lost its two capital ships *Prince of Wales* and *Repulse* to Japan off the east coast of Malaysia in December 1941. The Ottawa Conference in 1932 had established the principle of 'imperial preference', by which Commonwealth countries gave each other mutually agreeable tariff treatment. This meant that Australia provided Britain with raw materials, and Britain provided Australia with manufactured goods. Advanced technology or research came out of the UK or US; there was little recognised history of it being produced here. The ARL in Melbourne, founded by Lawrence Coombes in 1939, had spent the war trying to produce a little tank carrying an automatic heavy-duty machine gun, and failed for the entire six years.[14] After the war it was left supporting the Royal Australian Air Force (RAAF) and the Commonwealth Aircraft Corporation (CAC) in enhancing the capabilities of existing aircraft.[15]

Australia was also isolated by its great distance from the recognised 'centres' of 'western civilisation'. The quickest journey from Europe was three days' flight on propeller-powered aeroplanes directly descended from Second World War technology. These could only fly at low altitudes and were consequently hampered by bad weather, making long air trips 'tough and exhausting'.[16] There was therefore great local excitement in both public and private circles when the first commercial jet-powered airliner was flown in 1949.[17]

The Comet (1949)

The 'graceful, futuristic'[18] De Havilland DH-106 'Comet' certainly looked the part – gleaming metal, sweeping lines, and four advanced 'Ghost' jet engines nestled in the wings. A young Australian chemist named David Warren who had seen it at its debut at the Farnborough Air Show in 1949 later recalled being awe-struck at 'this wonderful bird' that offered the prospect of 'cutting the time to travel to Australia from three days to one.'[19] The Comet flew faster and higher than any commercial aircraft before it.

Unfortunately, as the forerunner of new aeronautic technology, the Comet was prone to accidents. Some were partly due to human factors, as pilots struggled to adapt to the flying techniques required by the new aircraft. The first major Comet incident was of this type – in October 1952 in Rome a BOAC pilot raised the nose too early, failed to become airborne and overshot the end of the runway. Although no-one was killed, the Captain was initially blamed. Later crash analysis of the accident – and another in March 1953 in which a

---

[13] Interview with David Warren, Caulfield, September 5, 2001; Thomas Alva Edison, c 1903, in *Harper's Monthly Magazine*, September 1932, referenced in the *Oxford Dictionary of Quotations*, Partington ed, Oxford University Press, 1996.

[14] Interview with Dr Bill Schofield, Director of the Aeronautical and Maritime Research Laboratories, Defence Science and Technology Organisation, Fishermans Bend, Melbourne, Thursday, October 4, 2001.

[15] Dr Bill Schofield, *The 1999 L.P. Coombes Lecture*, September 27, 1999.

[16] Marc Schaeffer, 'De Havilland Comet History', De Havilland Comet Website, http://www.oocities.org/capecanaveral/lab/8803/fcomet.htm, (link updated by Ken Fraser on 19 Jan 2013).

[17] Report of the Public Inquiry into the causes and circumstances of the accident which occurred on the 10th January, 1954, to the Comet aircraft G-ALYP, 1st February 1955.

[18] Job, *Australian Aviation*, above n 4, p 40.

[19] David Warren, in Maslen, above n 1, p 1.

Comet collided with a bridge during takeoff and caught fire, killing all aboard[20] – determined that the Comet takeoff technique needed to be refined.[21]

The cause of the next few crashes, however, proved more difficult to determine. A BOAC flight from Singapore to London, in May 1953, flew into a heavy tropical thunderstorm at 10,000 feet over India and disintegrated. Its remains were found over twenty square kilometres. It was followed in January 1954 by another BOAC Comet, on the same route, which exploded at 25,000 feet over the Mediterranean in daylight, witnesses reporting three blasts. All DH-106s were grounded and more than sixty modifications were made to the design, such as different fuel pipes, and the addition of fire and smoke detectors.[22] Engineers thought the problem had been solved, and flights recommenced on March 23. On April 8, another Comet exploded above Stromboli, Italy, with no survivors, and no witnesses.

Investigating the Comet Mystery, and Warren's Inspiration (1953)

The 'whole future of the Comet, and indeed of jet airliner operations as a whole, was suddenly in doubt'.[23] Sir Winston Churchill declared in the House of Commons – 'the cost of solving the Comet mystery must be reckoned neither in money nor manpower.' Local authorities were not underestimating the seriousness to Australia of delaying the jet age, either – they were 'greatly concerned' because 'everyone was waiting for the Comet to go into service on the Australia run.'[24] Soon after the Indian crash, in 1953, the DCA convened a meeting with Australian experts in all fields of aircraft design in Melbourne to discuss what may have been causing the crashes.[25] As this was part of the function of the ARL,[26] the meeting was held on its site at Fishermans Bend, and one of those invited was the young chemist, Dr David Warren. (Unfortunately, minutes of the meeting no longer exist in the archives – other participants are unidentifiable and only Warren's recollections survive. This is not particularly problematic, since the meeting's principal historical significance is probably the idea it sparked in the young inventor, not the technical expertise it contributed to the Comet investigation.)

Warren was at the meeting because he was an expert in fuel combustion at ARL, and it was possible that the Comet's fuel tank had exploded. Jet engines used a new fuel, kerosene – prior to that, aircraft used petrol – which had a different range of 'explode-ability' at varying temperatures and pressures. Others there were experts in areas like metal fatigue (an ARL scientist, H.A. Wills, had published a paper in the late 1940s which established the basic theory of aircraft fatigue used throughout the world today, and ARL had actually had the time and resources to do practical tests on 222 Mustang wings, data which are still used today).[27] They suggested that since the jet aircraft flew higher and faster than other aeroplanes, the added stress could cause the pressure cabin to burst at its weakest point, like a balloon. (Subsequent Public Inquiries in the UK found that this was indeed the reason for the Comet accidents: metal fatigue due to repeated pressurisation and depressurisation on parts of the fuselage like the corners of the cabin windows.)[28]

Each of the fifty to sixty people at this meeting presented a possible explanation for the accidents. Unfortunately, since the wreckage from each disintegrating Comet was the only evidence available (and it was usually spread over a wide area in small fragments), these theories were not provable. After Warren had presented his evidence, he waited while another thirty or forty people gave their opinions.[29] While he waited, in his own words:

---

[20] Macarthur Job, *Air Disaster*, Volume 1, Aerospace Publications, Canberra, 1994, p 13.
[21] Group Captain John 'Cat's Eye' Cunningham, De Havilland test pilot, developed the take-off procedure, still in use, of requiring the nose wheel of an aircraft to be kept on the runway until the specified takeoff speed is reached, when the aircraft is then 'rotated' into the climb attitude. Macarthur Job, above n 20, p 12.
[22] Marc Schaeffer, above n 16.
[23] Macarthur Job, *Australian Aviation*, above n 4, p 40.
[24] Maslen, above n 1, p 1.
[25] Ibid.
[26] Dr W.H. Schofield, 'Australian Research and Development for Military Aviation – Past, Present and Future', *Eleventh Dr Henry K. Millicer Lecture 2001*, October 16, 2001.
[27] Schofield, above n 15.
[28] Report of Public Inquiry, above n 17, paragraph 116 and others.
[29] Interview with Dr David Warren, Caulfield, August 29, 2001.

It went on for hours and hours … I didn't know anything about many of these specialised problems… I remember thinking about something I'd recently seen at the first Australian Post-war Trade Exhibition… I had gone along to see what inventions might be there, and the one that captured my mind was the Minifon recorder, the world's first 'pocket' [magnetic] wire recorder… it had a two-hour storage capacity. The thing I liked about it, too, was that it was good for speech or music, because it had a wide range of audio capacity, and my hobby was swing music. And the thought had come to me while the meeting droned on, that if Benny Goodman or some of my heroes came to Australia I could come along and sit in the front row for one pound two and threepence … and with a few spools of wire I could record them and copy them and share them with my friends. It's known as bootlegging now…

I remember then somebody getting up to say – 'could this have been a hijack?' Was it possible that in the middle of flying over India, a man had stood up and raised his hand in the air and said, 'I've got here a hand grenade, the pilot's going to take me to Cuba!' … Somebody mentioned 'How would we ever know?' Because everybody was dead, nobody could tell us. There was no record. It was at that stage that it clicked – two ideas both in my mind at the same time. One was how beautiful it was to have this pocket recorder, really designed for men to dictate things to their secretary. If there'd been a man sitting in the passenger seat with one of these, he might have been talking into it and if we'd been able to pick up that bit of wire out of the wreckage, we could play it over and we'd hear somebody saying, '…I've got here a hand grenade, if anyone moves I'll pull the pin!' Then you'd hear a rustle and people yelling out 'Grab him someone! Stop him! Don't let him let the thing go! Grab him!' Then you'd hear an explosion and you've got the answer.

It just could happen. And then I thought – yes, and if you put it up in the cockpit, if the cockpit people had said anything… whether it was 'hijack,' or whether it was just 'ow, I'm having trouble with this control,' or 'should we do this' or 'should we go up,' or 'what's wrong with the engine' or 'why has it stopped' – whatever they said there could also be recorded on one of these gadgets, and then taken out of the wreckage and give you an answer.[30]

Warren said no more in the meeting, but suggested to one of the other scientists at afternoon tea time that, 'I've just had a crazy idea. Why don't we make aeroplanes carry these little miniature recorders? It doesn't weigh much, they don't cost much, and when you think what they could do, it'd be worth fitting them.' And the answer was; 'Listen Dave, that might be a bit of an idea, but now's not the time to bring it up, because there wasn't any recorder in the wreckage… and this meeting is for the purpose of deciding what did happen or could have happened, not what we wish had happened.' This, coming from a man whom Warren respected, was 'the first clincher.' And, he remarks now in hindsight, 'it was, in a way, quite wise: it wasn't the time to bring it up. Because it didn't happen.' He talked it over with some of the other conference participants. Some (mostly the young ones) thought it was a good idea; most of the older ones could see problems.[31]

In the fabled public service tradition ('all good ideas go up, all work goes down'), Warren wrote a memo to the Superintendent of his section, Mr Bruce Kennedy, describing his idea, and asking what he should do with it: '1. Patent it? 2. Write a report on it? 3. Make one to prove how it works? Or 4. Put it in the waste-paper basket?' According to Warren, Kennedy told him: 'Dave, look, let's get it straight. You're not an electronics buff. You're a fuel chemist. Now leave these ideas to our instruments group and get on with your job of blowing up fuel tanks and seeing whether that could have been involved in the accident.' Dr Bill Schofield, the current head of AMRL, believes that Kennedy's response was a direct result of managers in those days staying in one particular division for their entire career; inevitably developing antagonistic 'fiefdoms'. In 2001, senior managers are moved around the entire organization to avoid this.[32]

The ARL Instruments Group leader agreed to 'have a look' at the idea, 'when we get a bit of time.' When Warren came back later, after he had finished with the Comet-type fuel tanks, to see what progress had been made by the Instruments Group, the answer was 'Oh? What idea?'[33]

---

[30] Ibid.
[31] Ibid.
[32] Schofield, above n 14.
[33] Ibid.

Technical Memorandum 142, and Silence (1954)

Warren really felt that 'there was nothing I could do', therefore, until early 1954 when he gained a new supervisor, Mr Tom Keeble. Keeble was more enthusiastic than Kennedy had been, and suggested that Warren write a formal ARL Technical Memo on the cockpit voice recorder idea to 'see what enthusiasm it produces.' Warren went back to his office and 'very quickly whipped out' Technical Memorandum 142 (TM-142), titled 'A Device for Assisting Investigation into Aircraft Accidents' and dated April 1954.[34]

In it he suggested that investigation of any aircraft accident would be greatly assisted by the development of a device 'which provides a record of flight conditions, pilot reactions, etc. for the few moments preceding the crash'.[35] It would make all the difference in determining whether the accident was the result of something of which the cabin crew would have had some slight warning – such as 'structural failure, meteorological abnormalities, error-of-judgment, over control by the pilot' – or by 'some sudden event of which the crew could have no warning or knowledge such as a fuel-tank or sabotage explosion.'[36] In the case of the Comet disasters, being able to determine whether there were in fact some common factors was of paramount importance. Warren explained the logic:

It may be assumed that in almost all accidents the pilot receives some pre-indication either by sight, feel of controls, automatic alarm or instrument reading. In most cases this would evoke a complaint of difficulty or a shout of warning to attract the attention of the co-pilot. Unless radio contact is actually in progress there is often not time to get any information through before the crash.[37]

Warren took an idle wish, silently voiced by accident investigators around the world, and explained how modern technology – that of wire recording, incorporated in the Minifon – could be used to achieve it. It was such a clear, concise proposal – anticipating as it does the main objections which would later be raised against the device (cost, privacy), and explaining so convincingly why voice recording is essential – that sections of it are worth quoting in full. Warren's experience in accident investigation as a chemical engineer was also clearly evident:

> To preserve the valuable evidence offered by these few seconds' conversation it is suggested that the following simple device could be fitted in all major aircraft, especially those in early stages of development. A small magnetic recorder could be made in which a continuous closed circle of steel wire passes an erasing head followed by a recording head in, say, a 2-minute cycle. Such a device would, therefore, provide a permanent "memory" of the conversation in the control cabin for the two minutes immediately prior to switching off, which would occur automatically in the case of an accident.
>
> This period is probably all that is required to give a clue to the trouble encountered. In the case of fire the period would almost certainly contain a shout from the first crew-member to detect it, followed by verbal instructions. Careless control or error-of-judgment (as is often suspected in landing and take-off accidents) would probably elicit criticism, suggestion or warning from the co-pilot. An unexpected fuel-tank explosion would be recorded as an interruption of normal conversation by the first part of the explosion noise followed by immediate cut-out.[38]

This first paper proposed a recorder of 'much less in size, weight and cost than a normal wire recorder' since it was only intended to record two minutes' worth of conversation, and 'neither high-fidelity nor play-back facilities' were required.[39] The device would be what is now known as 'fit and forget' – 'it could be automatically switched on with the engines and thus would not place any further burden on crew responsibility.'[40] Finally, Warren anticipated the objections the Australian Federation of Airline Pilots (AFAP) would make – 'the possible objection by crew to having their conversation continually recorded is

---

[34] D.R. Warren, 'A Device for Assisting Investigation into Aircraft Accidents', *Mechanical Engineering Technical Memorandum 142*, Aeronautical Research Laboratories, Research & Development Branch, Department of Supply, April 1954.
[35] Ibid., p 2.
[36] Ibid., p 1.
[37] Ibid., p 2.
[38] Ibid, p 2.
[39] Ibid., p 3.
[40] Ibid., p 4.

countered by the fact that the device has such a short memory. If no accident occurs, anything said during flight is obliterated during the time taken to taxi in.'[41]

Warren and Keeble sent the memo to the Melbourne agents for de Havilland, to the UK Ministry of Transport, to the related laboratories in Australia and the UK, and to the International Civil Aviation Organisation in Montreal – 'a few specialist readers'.[42] Warren recalls the result – 'weeks went by and we heard nothing. No comments, no queries, no enthusiastic taking it up.'[43] Keeble decided to republish the report and send it out again to a wider group; the second version went to all the Australian airlines, the DCA, the American Civil Aviation Authority (CAA),[44] and the Guggenheim Safety Foundation, 'thinking they should be as interested as anyone' – it was 'quite a big list compared with the first edition.'[45] Months went by, but still there was no response – not even in the form of someone else incorporating the idea into their own work.

Industry responds: 'A Solution Looking for a Problem' (1955)

Warren was still not prepared to let the idea die, and – prompted by a letter in Aviation Week describing a photographic flight recorder,[46] sent another memo, dated 31st October 1955,[47] to Keeble, who 'was much more sympathetic than anyone else had been up to that point'.[48] It was more than a year since Warren's proposal had been sent out, and he was concerned at the prospect of an inferior technology being adopted while his was ignored. He pointed out the disadvantages of the proposed photographic recorder, compared with his wire voice recorder – it would be more complicated, heavier and bigger, require additional equipment ('such as light sources'), more maintenance, and would need to be located in the cabin. Most importantly, it used a still camera taking images at discrete intervals, rather than producing a continuous recording: 'the photographic method would probably miss the critical moment which would reveal the prime cause of an accident.'[49] An 'all-seeing eye recording every slight error for later criticism' would have 'a detrimental psychological effect upon a pilot' which would not happen with the instrument of short memory that Warren proposed.[50] He concluded:

> As far as I know my memo has been distributed to the powers-that-be, considered and pigeonholed. I assume it is dead unless I resurrect it. No satisfactory explanation has ever been given to me as to why it was abandoned. Do you consider that it would be better left without further development or would it be worth:
> (a) Making up one unit to demonstrate its possibilities, at least to show its advantages over the proposed photographic methods.
> (b) Patenting the principle.
> (c) Sending a note to, say, Aviation Week.
> It is a pity to do this while it is still only a nebulous scheme on paper as this would be merely presenting any value the idea might have to some American firm for exploitation. In my opinion course (c) should follow (b) and/or (a). What think you?[51]

Keeble agreed with (a) and suggested that Warren make sure that the device would work, by going up in an aircraft, and seeing if pilots' conversation could be recorded over the background noise. He obtained a Minifon for Warren to use, despite the project not being official, by claiming it was effectively stationery ('we knew that the public service would get stuff for the office: that's their weakness'). They had to do 'a bit

---

[41] Ibid.
[42] Walby, above n 7, p 6.
[43] Warren interview, above n 29.
[44] Walby, above n 7, p 6.
[45] Warren interview, above n 29.
[46] B.F. Grimm, *Aviation Week*, February 21, 1955, p 53.
[47] D.R. Warren, Memo to T.S. Keeble, October 31, 1955, 3 pages, handwritten. Archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne,* Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.
[48] Warren obinterview, above n 29.
[49] Warren memo to Keeble, above n 47, p 1.
[50] Ibid.
[51] Ibid.

of surreptitious working in their own time.' Some of the younger members of the DCA, who thought it was a good idea, allowed Warren to travel in the cockpit of their aircraft on routine testing flights.

Neither Warren nor Keeble felt that they should apply formally for assistance; they were not certain that the person above, Chief Superintendent Coombes (and the people above him who were 'very limited in their "up-to-date-ness"'),[52] would approve it – and if it was formally rejected, Warren would be in real trouble if caught still working on it. Initial results were 'terrible – the engine noise drowned out everything.'[53] Warren realised that he'd need directional microphones and filters, to pick up just the voices of the two pilots. With the help of the Post-Master General (PMG)'s audio laboratory, he found that he could record and understand what was said.[54]

He had another idea at this time, too, that of adding flight data to the cockpit voice recording. The recording of instruments was not new – instruments called 'scratch recorders', which 'scratched' graphs on rolls of metal foil, already existed – but they were not yet designed to be used for crash investigation. The photographic and other recorders which were being publicised at that time were, however, for that purpose; Warren felt that he could do better. Applying his schoolboy knowledge of Morse code, he realised that he could record flight data by encoding it in a series of 'dots' at higher or lower frequencies than those used by human voice.[55] He suggested this in a memo to the Instruments Section, dated 1st November 1955,[56] but again silence prevailed.

When CAARC met for the fourth time, between November 11 and December 2, 1955, TM-142 was tabled as Paper 322. After some discussion 'it was agreed that in view of the practical difficulties of this subject … no action should be taken.'[57] Maslen quoted Warren in 1985 snorting at this remark – 'Have you ever heard of a new idea that didn't have practical difficulties? You could kill every step of man's progress with that statement.'[58]

John Bibo, then Technical Services Manager of Ansett, was a member of the Council and present at the meeting. He insists that the decision has to be considered in the perspective of the time, not with hindsight. The 'real problem' that concerned the Council was metal fatigue. The DCA, the airlines and the ARL were directing a lot of effort to trying to anticipate failures, and these were foremost in their minds; not the sort of failures that a voice recorder would pick up. ARL had actually invented a 'fatigue meter' in order to measure the strength and frequency of gusts encountered by aircraft. Further, although modern CVRs can record other audio clues to an incident, along with voice, the Minifon-based device could not pick those up. Therefore, Bibo recalls:

When David Warren came forward with the concept of a fairly unsophisticated voice recorder, it was just one more idea that somebody had thrown up. At that stage it wasn't going to be a major solution to any problem, because – particularly in the Australian environment – the problems weren't there at that time. It was a solution looking for a problem.[59]

Bibo and others recall that the ARL people 'were looked on as "boffins" to a certain degree' (as opposed to 'the hands-on approach of industry') – Schofield, the outgoing head of AMRL, describes it as 'the "home of the mad inventors" in those days'[60] – and from the Council therefore, 'there was no real strong confidence

---

[52] Warren interview, above n 29.
[53] Ibid.
[54] Ibid.
[55] Ibid.
[56] The memo from November 1955 no longer exists, but it is referred to in another Internal Memorandum dated February 8, 1957, from David Warren to the Acting Chief Superintendent of the ARL. This is archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.
[57] Commonwealth Advisory Aeronautical Research Council, Report of Meeting No. 4, Held in Australia, November 11 to December 2, 1955, C.C. 340, p 43. Unfortunately, only a copy of the front page of these minutes, annotated by Warren, actually survives. It is archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.
[58] Warren quoted in Maslen, above n 1, p 2.
[59] Telephone interview with John Bibo, Wednesday, October 3, 2001.
[60] Schofield interview, above n 14.

that something commercial would come out of there.'[61] Movements to make flight data recording mandatory were beginning overseas, in any case; and there was a great deal of resistance to the idea of voice recording, particularly from the pilots, who did not (and still do not) want to be under constant scrutiny in their workplace. DCA was indifferent; and the airlines 'had enough on their plate' and 'didn't want to be loaded down with any more technology' when 'there was not a perceived major problem calling for it.'[62]

Believing, incorrectly, that the CAARC had not discussed his device[63] (despite having received a verbal report that DCA 'were not interested')[64], Warren kept working on the CVR and experimenting with microphones[65] in his spare time throughout 1956.[66] (He figured out a method of ensuring that only sounds from the pilot's mouth were recorded, by drilling holes connected with tubing 'of such a length that the total distance from pilot's mouth to [microphone] capsule is the same for each hole,' so that only desired sounds would arrive in phase.)[67]

Mirfield's Prototype (1957)

In February 1957, The Age published a short article entitled 'Australian Invents Air Safety Device', about a spherical fire-proof crash recorder designed by a Western Australian electrical engineer named Robert Orgill.[68] The Sun showed a photograph of Orgill and his invention (two hemispheres with cork-like stubs of foam spaced evenly over the surface) under the uninspired headline 'On the ball for air safety'.[69] Warren quickly penned an Internal Memorandum to the Acting Chief Superintendent of the ARL asking what had happened to TM-142.[70] Since there was general interest elsewhere in such a device, he challenged –

> I would appreciate some definite directive as to what further action, if any, should be taken here at ARL. Should a prototype be built, or can some reason be put forward to show why the idea should be abandoned? Acceptance, criticism or condemnation of an idea are all acceptable. Only apathy is demoralising, the more so when the idea is taken up by others.[71]

Keeble wrote at the bottom of the page, 'I fully agree with this.'

Warren attended a demonstration of the Orgill device on the 26th of February and wrote a two-page handwritten analysis, finding the 'ball' conception 'excellent' but noting that in the demonstrated version 'nothing was said of how the speech would be picked up' and that 'no ejector system was demonstrated.'[72]

At Keeble's suggestion, Warren took some sketches of his idea to an instrument maker called Tych Mirfield. ARL would provide him with two £200 Minifons in order to make it (one would run backwards while the other recorded, and then they would switch); Mirfield said it would cost £1000. Warren asked Keeble for the funds, and Keeble explained that for any amount over £600 he had to ask head office, which, since nobody had expressed interest, would say 'no'. Warren went back to Mirfield and explained that ARL could only afford £600. He recalls Mirfield getting very annoyed and demanding – 'I've got to eat! You get your salary!' Warren promised that if Mirfield made the prototype for £600, they would put his name prominently on it, and 'if the idea catches on world-wide, you'll be proud to say you were one of the originators of it.' He

[61] Bibo interview, above n 59.
[62] Ibid.
[63] Warren, Internal Memorandum dated February 8, 1957, above n 56.
[64] Ibid.
[65] David R. Warren, 'Tests in the Development of a Crash Recorder', *Mechanical Engineering Technical Memorandum 180*, Aeronautical Research Laboratories, Research & Development Branch, Department of Supply, April 1958.
[66] Warren interview, above n 29.
[67] D.R. Warren, 'Crash Data Recorder: Description for Patent Application', First Draft, November 1958, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser, p 3.
[68] 'Australian Invents Air Safety Device', *The Age*, February 8, 1957, p 14.
[69] 'On the ball for air safety', *The Sun*, February 3, 1957, p 7.
[70] Warren, Internal Memorandum dated February 8, 1957, above n 56.
[71] Ibid.
[72] David Warren, 'Orgill Flight Recorder', handwritten memo dated 'after February 26, 1957', two pages, p 2, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

also promised to include Mirfield's name as an author in his next report on it – Mirfield 'softened at this' and, in his deep German accent, said, 'Alright, I will do it!'[73]

Mirfield's model was ready for demonstration by the end of 1957. It was the part of the recorder which sat in the asbestos-and-steel fireproof box and was designed to survive a crash with the wire undamaged. The 1960 ARL team added enhanced electronics to the recording circuit (external to the box), and an advanced ground-station, but the Mirfield model remained largely unchanged until Davall & Sons reshaped it to fit into their 'Red Egg' recorder in 1963. It had a four-hour storage capacity for eight instrument channels. They tested it on a DCA aircraft in September, with the permission of the Director-General of the DCA.[74] It worked, proving that Warren's idea was sound, although instrument readings were not particularly accurate. Mirfield's name appeared on the unit, and he was named as joint author of Warren's report on the device in the Australian Journal of Instrument Technology.[75]

At the beginning of 1958, Keeble and Warren took the unit to show Coombes, who was reportedly 'delighted.' Warren recalls Coombes then officially notifying DCA that they had a working unit, and requesting an assessment. H.A. Wills, acting for Coombes, wrote to the DCA on June 13, 1958, to ask for it 'to reassess the value of the project' in light of a forthcoming CAA (in the US) requirement 'for the fitting of crash recorders to high-flying aircraft',[76] a proposal for which had been received at ARL the day before.[77]

Peter Langford, the head of the Airworthiness Branch of the DCA, acting for the Director-General, wrote a reply which has fuelled charges against the department ever since.[78] Dated 4th July 1958, one sentence has been used to condemn it for a lack of foresight: 'Dr Warren's instrument is really intended for a fundamentally different purpose to those required by the [US] Civil Air Regulation 42.22[79] and, consequently, it has little immediate use in civil aircraft.'[80] Almost every article about Warren's 'black box' since Maslen's has quoted this sentence to demonstrate that the bureaucracy was 'myopic'. They do not quote the next paragraph:

> We would like to see Dr Warren's instrument developed to a prototype stage, fitted to an aircraft and evaluated properly before passing further comment on it as we feel that it has value as a crash recording device suitable for use in hazardous test flying and early service evaluation flying with new aeroplane types. Towards this end, we would be prepared to arrange for trials should your Department develop the instrument to the stage suitable for aircraft installation. We regret that because of very heavy outlays in fatigue work and associated studies on aluminium alloys we cannot contribute financially towards the development of the instrument itself.[81]

From the point of view of the DCA, it was not their responsibility. With some frustration, Langford now clarifies:

---

[73] Warren interview, above n 29.

[74] Len C. Jacobe, for the Director-General, DCA, letter to Flight Superintendent, Australian National Airways, August 30, 1957. Archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[75] T.N. Mirfield and D.R. Warren, 'Miniature Wire Recording Decks with Limited Memory', *Australian Journal of Instrument Technology*, Society of Instrument Technology Australia, Vol. XX, No. 2, May 1964, pp 94-100.

[76] HA Wills, Acting Chief Superintendent, letter to Director-General, Civil Aviation Department, June 13, 1958. Archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser. ARL File B2/010.

[77] 'CAA-CAB Instrument Standard for Aircraft Flight Recorder', June 12, 1958, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[78] Peter Langford, letter to the Chief Superintendent, ARL, July 4, 1958, three typed pages, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[79] Regulation 42.22 demanded that, for American planes operating above 25,000 feet, 'an approved flight recorder which records time, air speed, altitude, vertical acceleration, and heading shall be installed … and shall be operating continuously during flight time.' Ibid, para 11, p 3.

[80] Ibid, para 15, p 4.

[81] Ibid, para 16, p 4.

The system failed for one reason and one reason only. Dr Warren believed that DCA should take his recorder, arrange for it to be manufactured, and make its use mandatory. It failed because he would never listen to us when we said that our role was purely safety and that an aircraft would be no less likely to crash because it had a recorder installed. He would never understand that it was ARL's responsibility to have an operational recorder made with provisions for subsequent production and have it submitted to us for approval. Finally, he would not understand that we could never make anything mandatory until we could see that means were available to meet that requirement… [We did] once in the past, the equipment failed and we had to revert to our original requirement at great expense to the airlines. We were unlikely to fall into such a trap again and the Airlines would have refused to comply and gone political if we ever did.[82]

He notes – 'Why should we pick this one out [of other projects]? Were we expected to be as enthusiastic as Warren was? That would be totally unrealistic.'[83]

A week later, W.B. Kennedy, Scientific Adviser to the Chief of the Air Staff at the RAAF, wrote to Coombes. Warren proposed, since the RAAF Sabre aircraft were being lost with 'disturbing frequency' and 'there were plans to switch over to the Mirage', that he could 'make a [small] recorder which would tell them what had gone wrong if one of their aeroplanes crashed.'[84] Kennedy explained that from the RAAF's point of view, no matter how small the recorders were, the rewards for installing them were even smaller, 'even presuming the recorder enabled solution of the majority of otherwise unexplainable accidents. Opinion is,' he wrote, with some wit, 'that, in fact, the recorder would yield more expletives than explanations.'[85] He added, apparently so as not to be 'too discouraging', that 'to the RAAF, loss of aircraft is an accepted risk with a predictable cost.'[86] Warren notes that 'presumably, so were the pilots,'[87] and it was not until very recently (1992) that the RAAF was required to include CVRs in its aircraft.[88]

The Englishman (1958)

Warren had reached an impasse – without external funding, which he and the ARL believed should come from the DCA (since it had money to spend on aircraft safety research), the 'ARL Crash Recorder' could not be developed further. However, in the interim, serendipity intervened.

One lunch-time in June 1958, Warren remembers, he was working on the unit when Coombes came into the room with a complete stranger, and said, 'Dave, I've got here a friend – tell him what you're doing. Tell him about your idea.' Warren described the function of the 'Flight Memory Unit'. When he paused, 'a very English voice' announced – 'I *say*, Coombes, *old chap*. That's a damn good idea. Put that lad on the next Courier and we'll show them in London.'[89] The voice was Robert Hardingham, Secretary of the Air Registration Board in the UK. Warren looked to Coombes, who 'had a twinkle in his eye' and said: 'what are you sitting there for Dave? You heard what the man said. Get your passport ready.' In hindsight, Warren notes – 'Coombes knew that this was the breakthrough we'd been longing for.'

A little over a month later, Warren was on his way to England, and the cockpit voice/flight data recorder was about to leave contemporary obscurity.

---

[82] Langford email, September 28, above n 12.

[83] Peter Langford, email, October 13, 2001.

[84] Maslen, above n 1, p 2. A handwritten note dated 26/1/60 mentions a 'meeting between D.R. Warren and members of RAAF (thru Fl/Lt Bob Bertram) re probable use of recorders in Mirage… see Mech Eng Contacts Book' – archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[85] W.B. Kennedy, Scientific Adviser to Chief of the Air Staff, letter to Chief Superintendent, ARL, circa July 12, 1958. Archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[86] Ibid.

[87] Warren, in Maslen, above n 1, p 2.

[88] 'Voice recorders urged', *The Age*, Friday July 10, 1992, p 3.

[89] Interview with David Warren, Caulfield, Wednesday, September 5, 2001.

Chapter Two – The Hunt for Manufacturers

> In the aircraft industry, Australia was – and still is – a buyer and a user. It does not have the infrastructure or the financial capital to manufacture aircraft or complex aircraft components except under licence to foreign manufacturers. Thus, in the 1950s, ARL had to sell its ideas offshore.
>
> - Frank Yeend, Air Safety Investigation Branch.[90]

This second chapter explores the complexities of the subsequent 'black box' history that are completely ignored within the literature. The work of the ARL team, now publicly recognised, but never investigated, is explained in this context. The ultimate decision of the Australian airlines to use American tape recorders instead of the Australian wire recorders is also discussed in depth for the first time. This chapter presents an analysis of previously ignored primary materials, and endeavours to represent a balanced contribution to the almost non-existent secondary writing on the subject.

England, Canada and America (1958)

Warren and an assistant (possibly named Hurley) visited the UK in early August, on a converted four-engined RAF Hastings bomber which became a three-engined aircraft between the 'unbearable desert heat' of Tunis[91] and the 'torrential hail storm' that greeted them in England.[92] Warren sat with the Minifon on his lap 'and gave a verbal account of everything that was happening, with the feeling that if we do lose another engine and crash, I would have proved the bastards wrong … unfortunately, we didn't crash!'[93]

He presented a version of TM-142 to the Aeronautical Research Council in London on August 8, 1958[94] and showed them the unit made by Mirfield. (The Commonwealth Air Transport Council later distributed copies of this report 'widely'.)[95] On the 27th Warren gave a lecture at Berkeley Square House at which officials from various branches of the Civil Service and a representative from Bristol Aircraft asked questions and made comments. One of the officials, a Mr E. Newton of the Accident Investigation Branch, made the earliest recorded description of the device as a 'black box'.

Their English hosts were enthusiastic. 'To their great surprise,' Maslen noted in his article, 'the Australians were treated like heroes.'[96] The BBC interviewed Warren for television and radio newsreel on the September 17, 1958, which they broadcast at 5.30 in the evening.[97] It caught the attention of four British aircraft

---

[90] Frank Yeend, Inspector of Accidents, Air Safety Investigation Branch (later Head), email, October 1, 2001.

[91] Michael Bachelard, 'Hail to the backroom boys: A group of quiet achievers has been churning out world-beating inventions on a wing and a prayer for 60 years – and they're still going strong', *The Australian*, Features, Tuesday, January 19, 1999, p 11.

[92] D.R. Warren, postcard to L.P. Coombes from Coventry, UK, September 8, 1958, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser. According to the postcard, the 'eventful' trip over also featured 'dysentery from the water in Karachi, a day's lion hunting in Nairobi, and the usual delays for radio and electrical faults.'

[93] Warren, quoted in Bachelard, above n 91.

[94] D.R. Warren, 'A Device for Retaining Data in Aircraft Accidents', published as an A3 Report, No ARC 20,358, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[95] K.C. Lang, telegram to L.P. Coombes; and Coombes, telegram to Lang, October 14, 1958 and shortly afterwards; archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[96] Maslen, above n 1, p 2.

[97] Dr David Warren, Interview with Reginald Turnill, BBC, Reference 01/PC/KMK, confirmation sheet dated Thursday, September 18, 1958. Unfortunately, only the mute prints still exist. A search of the BBC Library in June 1996 revealed that the sound reels had been lost; Fax from Robin James, BBC Library Sales, to Dennis Callegari, Department of Defence in Australia, June 25, 1996, both of these documents archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

manufacturers – Bristol Aircraft Ltd, Fairey's, Avro's and Vicker's.[98] M.W. West, Chief Observer for Bristol wrote to congratulate Warren – 'Your talk on Radio Newsreel came over very well indeed – congratulations on enlightening the masses!!!'[99] English instrument makers Electric Music Industries (EMI, who were the Minifon licensees in the UK), Epsilon Ltd and Ultra Electrics (which had the licence to produce the Canadian National Research Council (NRC) 'Crash Position Indicator' in the UK) expressed an interest in developing the recorder in exchange for 'exclusive rights for their own commercial protection.'[100] EMI wrote to Coombes on the 1st of October to ask what was the next step; but Ultra withdrew because they felt 'at this stage … there is no market for the Recorder as it stands.'[101]

On the 2nd, Warren flew on to Canada[102] to meet with the NRC in Ottawa, to investigate the idea of combining the 'Flight Memory' with a crash-locating beacon they had developed.[103] In the United States on the 6th,[104] Warren examined a Lockheed recorder which he had read about in Flight in February[105]; a letter from Coombes in November, after Warren had returned and been debriefed, noted that this was 'a very clumsy recorder which is not only large and heavy but has no memory and the whole record must be read laboriously with a microscope; it is also not crash proof. I therefore hope the UK will decide to back up the [ARL] recorder.'[106] In Technical Memorandum 187 (TM-187) in November, Warren noted that Pan American Airways 'like most other American Airlines' was 'not content with [the Lockheed] recorder' which was heavy and bulky.[107] Nonetheless, there was no interest in America for Warren's device: 'the Americans quite clearly stated that they were not interested in anything invented outside the USA.'[108] The authorities declined to attend a demonstration at the embassy.[109]

[98] D.R. Warren, 'ARL Flight Memory Project Part III: Reactions to the ARL Accident Recorder Project in United Kingdom, Canada and United States of America', *Mechanical Engineering Technical Memorandum 187*, Aeronautical Research Laboratories, Australian Defence Scientific Service, Department of Supply, Melbourne, November 1958, p 4.

[99] M.W. West, Bristol Aircraft Limited, Bristol, England, postscript in two-page letter to D.R. Warren, October 1, 1958, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[100] D.R. Warren, postcard to L.P. Coombes, from Australia House, London, dated September 22, 1958. Archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[101] V.G. Sampson, Ultra Electric Limited, Acton, London, letter to K.C. Lang, Esq., Department of Supply, November 7, 1958, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[102] Unclassified telex from H.B.K. Burgh, 'Austarm London' to 'Austmil Washington', September 29, 1958, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[103] Warren interview, above n 13.

[104] Burgh, above n 102. The *Flight* issue of February 21, 1958 which apparently contained this reference is no longer available.

[105] Ibid.

[106] L.P. Coombes two-page typed letter to Sir Harold Roxbee-Cox, November 3, 1958. Archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[107] TM-187, above n 98, p 6.

[108] Ibid.

[109] Warren interview, above n 13.

EMI's Six Months (1960)

On the 25th of November 1958, R.B. Reynolds of the EMI division in Salisbury, South Australia, proposed to ARL that EMI undertake to manufacture the 'Flight Memory' under a 'similar formula to that used in the case of Xerography'[110] (the technique for an important part of the 'dry' copying process having been invented at the ARL's sister laboratory in Salisbury some years before).[111] Coombes felt that EMI had the best claim to produce the crash recorder because it: (a) 'had wide experience in all the fields involved (recording, telemetry, transducers, multiplex switching, acoustics)', (b) held the Minifon licence, and (c) was willing to produce the unit in Australia, 'thus retaining its prestige value'.[112] In a letter dated December 9 he ordered a 'transfer of the project' noting that ARL's 'assets are purely "know-how" as no patent-rights have been taken out.'[113] Dr Warren was sent to Salisbury within the week and EMI took over immediately after Christmas,[114] intending to patent in England, manufacture in Sydney, and 'get the article on to the market as early as possible at the lowest possible price'.[115]

In the meantime, since EMI did not care what the device would be called,[116] Coombes suggested that it be called 'The AUSTRAL Flight Memory', a name which used neither the words 'crash' nor 'recorder', and which kept the 'Australian' tag in such a way that a clever logo could make the initials 'ARL' prominent.[117] This never happened. The same day, December 23, 1958, the Federal Minister for Supply (the Hon. Alan Hulme) publicly 'announced' the development of the crash recorder. Both The Age[118] and The Herald[119] carried stories describing Warren's device in reasonable detail. Mirfield was ignored in these articles, and wrote to Hulme demanding that proper recognition be given[120] - then again, as Warren pointed out in the ARL reply, the articles did not mention any ARL people by name, either (The Age article, which Mirfield saw, did not even mention Warren).[121] Mirfield had done commendable work, but mentioning it in a press release 'would be a courtesy which we may now regret having overlooked rather than a right which could now be demanded.'[122]

EMI worked on the unit until June 1959, when it withdrew – at a stage where, in its own opinion, 'the airborne electronics were completed and appeared quite successful'. Reynolds had visited the EMI head office in England and inadvertently brought the project 'under the close scrutiny of our financial experts

---

[110] R.B. Reynolds, EMI Electronics, Salisbury, to L.P. Coombes, letter dated November 25, 1958, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[111] Schofield interview, above n 14.

[112] L.P. Coombes, letter to Controller, Research & Development, December 9, 1958, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[113] Ibid.

[114] R.B. Reynolds, letter to L.P. Coombes, December 15, 1958, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[115] R.B. Reynolds, letter to Mr McDonough, January 28, 1959, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[116] R.B. Reynolds, letter to Coombes, January 28, 1959, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[117] L.P. Coombes, 'Name for ARL Crash Recorder', note to Controller, Research and Development, December 23, 1958. Archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[118] '"Memory" May Find Plane Crash Causes', *The Age*, December 23, 1958, p 7.

[119] Kenneth Green, 'Planes will get "memory"', *The Herald*, December 26, 1958.

[120] T.N. Mirfield, Chartered Engineer, London, letter to Mr Hulme, December 29, 1958, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[121] D.R. Warren/F.W. David, draft internal memorandum to the Controller, Research and Development Branch, January 15, 1959, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[122] Ibid.

there' who advised that he 'must no longer proceed with it … there is much more work involved in the mechanical design than we had first believed.'[123] Reynolds explained, apologetically, that 'the costs … appear to be of the same order as, or greater than, the expectations of profit.'[124] EMI gave the whole project back to ARL ('here's everything we've done, free of charge, you do something about it'),[125] which was left to begin again, trawling sadly through the industry in search of commercial backing. In October, Dr BG Gates, Controller of Research and Development, wrote to the UK Ministry of Aviation, noting:

> We are not following up the project any further at ARL. However, should the Ministry of Supply feel strongly that the device would be of value to them, we would be prepared to reopen the matter, with a view to assisting development in UK.[126]

Eventually, in December, a reply came back:

> There is considerable interest in the United Kingdom for a device of this type and the Air Ministry is in the process of writing an Operational Requirement.[127]

The Operational Requirement, No. O.R./8003, decided on January 25, 1960, set a requirement for flight data recorders to be in service on all aircraft by the end of 1961. In February Coombes wrote to Reynolds asking if EMI 'could produce one airborne electronics unit for us on a contract basis.'[128] Unfortunately, the EMI person directly concerned had left and EMI suggested 'with regret' that ARL ask the local PMG Instrument Division to do it.[129]

The Mackay Disaster (1960)

The jolt which revived the project was the mysterious crash on Friday, June 10, 1960, of a Trans Australian Airlines (TAA) Fokker Friendship, which crashed into the sea off Mackay in north Queensland, killing all 29 people on board. It was a national tragedy, with the added angle that nine of the passengers had been schoolboys who had 'begged' to fly.[130] Now there was a clear example, in Australia, of why a cockpit voice/flight data recorder could be critical in an investigation. Senator Shane Paltridge, the Minister for Civil Aviation, called a full, open public inquiry. The Board of Accident Inquiry, with Justice Spicer as Chairman, sat for thirteen days in Brisbane from October 4.[131] Spicer was 'highly impressed and lavish in his praise' of the DCA investigation team's work.[132]

By December, the Inquiry had heard all submissions and was ready to give its findings. However, it 'found it impossible to reach any firm conclusion on the cause of the air disaster', Spicer describing it as 'well nigh

---

[123] R.B. Reynolds, letter to Coombes, June 8, 1959, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[124] R.B. Reynolds, letter to Coombes, June 4, 1959, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[125] This is not a direct quote from EMI; this is Warren's recollection of the handover, interview above n 13.

[126] B.G. Gates, letter to S. Scott Hall, Head of Staff, UKMOAS, 'ARL Flight Memory', October 26, 1959, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[127] S. Scott Hall, letter to B.G. Gates, 'ARL Flight Memory', December 15, 1959, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[128] L.P. Coombes, letter to R.B. Reynolds, February 9, 1960, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[129] M.F. Bion, letter to D.R. Warren, February 22, 1960, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[130] 'Boys "begged" to fly', *The Sun*, Monday, June 13, 1960, p 3.

[131] Macarthur Job, *Air Crash*, Volume 2, Aerospace Publications, Weston Creek, ACT, 1992, pp 163-173.

[132] Ibid, p 169.

inexplicable.'[133] The pilot might have 'placed undue reliance on visual observation at the relevant time';[134] the instruments might have malfunctioned; or a sudden unpredictable emergency (the TAA director of Engineering, John Watkins, thought that a bottle found in the wreckage of the cockpit might have been something brought up there by one of the boys which filled the cockpit with 'pungent, heady fumes'…) might have caused the accident.[135] Evidently, for the sake of preventing a recurrence, knowing which had occurred was very important.

Explaining that it was 'not the [DCA] inspectors' fault that in the end they had not solved [the] accident', John Starke, QC, for the DCA, told the Board – and was quoted in the newspapers – that DCA 'had been working on [a unit] since 1955' which would record 'readings of all vital instruments while a aeroplane was in flight, and any conversations between pilots.'[136] Warren was incensed – they must mean ours! He wrote to Coombes:

> DCA have NOT been working on it 'since 1955'. In actual fact hardly anyone has been working on it either then or now, for the very reason that we have never had the necessary backing – either financial or by statement of a definite requirement – from the appropriate authorities. For example, it was the lack of a DCA requirement that was given as a reason by HJ Brown as why Rola would not undertake the project. Should the court not be informed (via FSS, perhaps) that the development of the device has always been and still is an on-and-off part-time project because no firm decisions have ever been made. If the Judge wished he could then exert a little pressure in his summing up, instead of assuming that the device is being developed at full speed and is 'just around the corner'.[137]

Coombes wrote to Anderson, the Director-General of the DCA - 'I feel that the position is unsatisfactory as far as ARL is concerned. If the recorder has real potential value, we should be developing it; if not, it should be abandoned. As it is, we are uncertain and precious time is slipping by.'[138] In an earlier letter he had expressed frustration with the DCA attitude – 'while [they] might well wish for some further development, the market in Australia alone would not justify any real effort in engineering for production.'[139]

On the other hand, as Langford later pointed out, just as the DCA received funding for its own functions, ARL also received its funding from the Department of Supply for research. The DCA, he asserts, 'had no mandate to assist any organisation – either government or private – in the development of commercial products.'[140] Anderson replied to Coombes; 'we will continue to co-operate in every way possible in the development of your recorder… I did not wish to give you the impression that we would not co-operate any further with you, but rather that the responsibility for development must rest with your organisation.'[141]

Whether Warren's concerns were actually ever transmitted to the Judge, or whether it was just a fortunate coincidence, Spicer's orders solved the problem. Starke had conceded that 'if these instruments can be perfected to the stage of being installed in machines and relied upon when there is a crash, they must be a very excellent idea' but he claimed that 'the Department has not yet had presented to it one of these instruments which is sufficiently perfected… to install.'[142] In response, Spicer simply made the clear 'recommendation', for 'continued research to develop a flight recorder', which was accepted by the Minister,

---

[133] 'Mackay Air Disaster Remains Mystery After Board Inquiry', *The Age*, December 12, 1960, p 3.

[134] Ibid.

[135] Job, above n 131, pp 172-173.

[136] 'Evidence Ended at Air-Crash Inquiry', *The Age*, November 5, 1960, p 3; and 'Pilot Error "Not Ruled Out", QC Says At Crash Probe', *Melbourne Sun*, November 5, 1960, p 4.

[137] D.R. Warren, handwritten memo to Chief Superintendent, November 9, 1960, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[138] L.P. Coombes, letter to Mr D.G. Anderson, Director-General, DCA, November 29, 1960. Archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[139] Coombes letter to Roxbee-Cox, above n 106.

[140] Langford, above n 82.

[141] D.G. Anderson, letter to L.P. Coombes, January 23, 1961, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[142] Starke QC, for the DCA, Excerpt from Transcript of Friendship Accident Enquiry, December 13, 1960, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

Paltridge. Paltridge announced that the Department would order 'the installation of equipment to record talks between the captain and first officer of a aeroplane to show what happened in a aeroplane's last few minutes before a crash and readings of the aircraft's instruments.'[143]

The ARL recorder was suddenly, in December 1960, the focus of praise in the newspapers. The DCA commended the ARL for having made 'a very practical contribution in this very complex field.'[144] Hulme, 'opening the [ARL] laboratories for inspection', stated that 'great work was being done by the 400 people employed there.'[145] Warren even managed to express some of his frustration with its progress in The Sun - 'because of our air safety record, selling crash investigation equipment in Australia is like selling a refrigerator to an Eskimo'[146] – however, the aviation writer explained no more, leaving Warren to look slightly churlish in the face of praise. The Age hinted at Warren's difficulties by noting that the DCA 'has until now been wary of putting a flight recorder into the airlines where it might not be regarded favourably by both pilots and executives.'[147]

Objections of The Australian Federation of Airline Pilots (1960-1980s)

The pilots were cautious. B.I. Crofts of the AFAP – then an extremely powerful union - told the newspapers that 'we would object if it was used as a spy flying alongside the pilot.' Later, he expressed fears that 'this instrument could become a "Big Brother"'.[148] The AFAP (and its American counterpart, the Air Line Pilots Association, ALPA),[149] have ever since demanded strict legal protections for pilots where CVRs are installed.[150] Whilst the AFAP agreed that CVRs be used for accident investigation where the crew had not survived, it did not agree that pilots should work in an environment in which evidence from CVRs could be used against them in a court of law. Other workers were not under constant surveillance; it was an 'invasion of pilots' privacy'.[151] The pilots were being asked 'to accept an intrusion into their workplace the like of which had never happened before… they had no control over the use of the device (yet would be responsible for it) and no knowledge about where and how the information gained would be used either by their companies or by the Courts.'[152] Legislation had to weigh the need for courts to have at their disposal, as a matter of justice, all relevant evidence in a case,[153] and the threats of the AFAP to take serious industrial action if pilots were not protected.

When in February 1983 a TAA A300 was hijacked enroute from Perth to Melbourne by a man who wanted to be taken to the Franklin River Dam site, the Victorian Police Force demanded the CVR 'so that a voice analysis could be conducted, positively placing the hijacker in the cockpit.' The TAA Flight Operations Manager refused to produce the CVR; so the police obtained a search warrant and seized it. The AFAP immediately passed a 'directive', allowing the President of the AFAP to instruct all Australian pilots to de-activate the CVR – if someone managed to read the tape, this would be enforced. As it happened, the police could not decode the tape, and the Bureau of Aircraft Safety Investigation (BASI) was instructed by Department of Aviation not to transcribe it.[154]

---

[143] 'Pilots Oppose Recorders – "Like spy flying alongside"', *Melbourne Herald*, December 12, 1960, p 3.

[144] 'Pilots Oppose Recorders', above n 143.

[145] Sun aviation writer, 'Praise for Air Safety Record', *The Sun*, Tuesday December 13, 1960, p 8.

[146] Ibid.

[147] 'New Recorder Could Tell Why Planes Crash', *The Age*, Tuesday 13 December 1960, p 5.

[148] 'Guarantees Wanted On Cockpit Voice Records', *The Age*, Wednesday, September 16, 1964, p 12.

[149] FAA Conference on Airborne Recorders, March 19, 1963, fragment archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser, p age 8.

[150] Gareth Evans, Attorney General, to Kim Beazley, Minister for Aviation, Canberra, December 23, 1983.

[151] The AFAP contends that 'no other class of person is subjected to continuous electronic eavesdropping in his place of employment'. Letter from Kim Beazley, Minister for Aviation, to Gareth Evans, Attorney-General, May 27, 1983.

[152] Morna Kenworthy, letter to Jeremy Sear, 17 October 2001.

[153] Mason J, <u>Australian National Airlines Commission v The Commonwealth of Australia and Canadian Pacific Airlines Ltd</u> 91975) 132 CLR 582.

[154] Capt G Reinke, Vice-President (Technical), AFAP, letter to Executive Secretary, IFALPA, England, March 16, 1983, held by AFAP, Melbourne.

The 1984 amendments to the Air Navigation Act 1920 provided legal protection for flight crew members against the use of CVR information, formalising a 1975 'gentleman's agreement' with the AFAP and making 'CVR evidence inadmissible in any criminal proceedings against crew members' and prohibiting it 'from being used by a person to take disciplinary action against an employee'. These were moved to Sections 19HE to HH in 1995, leaving CVR evidence unusable except subject to an order of a court in civil proceedings not against a member of the flight crew.

The ARL Instruments Team – Sear, Boswell and Fraser (1960-3)

While the Inquiry was taking place, there were two other developments. In July, the US Federal Aviation Agency (FAA) announced Civil Air Regulations Amendment 40-27, effective August 18, 1960, requiring the installation of data (but not voice) recorders in all 'turbine-powered' aircraft in the US.[155] In August, the ARL in Australia decided 'to press on again with making a full airborne prototype ourselves',[156] with assistance from the DCA (in the form of aircraft provision, mainly).[157] (The DCA people were perhaps surprised when they were later written as the 'villains' of the tale; they had assumed that they would be remembered for helping the ARL.) Warren wasn't an electronics expert, so ARL provided him with a team from the Instruments Group, under Gerry Rundle[158] – 'we'll give you some of these blokes who are geniuses – Lane [Sear], Wally [Boswell] and Ken [Fraser].'[159]

ARL was 'quite an extraordinary place to work in those days', Schofield recollects, where they worked on 'mad' schemes, like Warren's later 'Belsen Bunny-Bumping Box' (a device for determining how much carbon monoxide was required to poison rabbits), and more serious ones, like the guidance system for the Ikara missile. 'We did whatever we thought was a good idea; we had lots of money, we didn't have customers, we didn't produce anything, and we certainly didn't want to have anything to do with industry.'[160] (This does not entirely square with their earlier inability to find funds to pay Mirfield.) Sear's assistant at the time, Marie Welch (now Ferrari) remembers it as 'a good place to work. Nobody ever seemed to be in a hell of a hurry or anything, it was pretty calm.'[161] The ARL site, down by the Yarra River on Fishermans Bend, was a 'university without students',[162] populated by middle-aged 'boffins' like Sear and Boswell (Fraser was much younger, in his early 20s), working away on esoteric projects. They wore tweed jackets, smoked pipes, and worked up time during the week so they could spend much of Friday afternoon at the South Melbourne hostelry.[163] These surroundings are important to note because this is the appearance ARL conveyed to the industry. That such high-quality technical work was produced there was perhaps surprising given first impressions of the environment.

Sear, the senior scientific officer, was 'a little eccentric', Welch remembers – but a 'very quiet sort of fellow … very nice to work for.'[164] An accomplished swimmer in his youth,[165] he now enjoyed tinkering with

---

[155] US Federal Aviation Agency, Civil Air Regulations Amendment 40-27, July 12, 1960; also FAA News, Office of Public Affairs, Washington DC, Number 85, July 19, 1960; both archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[156] David Warren, letter to Peter Turner, TAA, August 15, 1960, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[157] D.R. Warren, letter to Mr Ellwood A. Randolph, Lockheed Aircraft Service, Inc, August 15, 1960, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[158] It is impossible to firmly determine the date beyond August, 1960, because it is not in the documentary record and all that Warren will say is that 'in scientific circles, 99% goes on unofficially.' Warren interview, above n 13. In any case, an exchange of letters between Rundle and Warren on October 26 and 28 respectively over technical queries confirms that by October, work was well under way. These letters are archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[159] Warren interview, above n 13.

[160] Schofield interview, above n 14.

[161] Telephone interview with Marie Ferrari, née Welch, Thursday, October 4, 2001.

[162] Schofield, above n 14.

[163] Interview with Mrs Edna 'Dinah 1' Boswell (widow of Wally Boswell), September 22, 2001.

[164] Welch interview, above n 161.

[165] Awards in Sear family private papers, used with permission from David Sear.

whatever he could get his hands on, be it cars or Russian television sets. Fraser remembers him having a strong grasp of 'extremely tricky things' 'built up from experience and know-how'.[166] Boswell was a 'very skilled' technical officer who excelled at making very precise, 'beautiful' electronics and models.[167] Sadly, since Sear preferred actual electronics work to writing reports,[168] and since both he and Boswell firmly adhered to the public service rules which stated that work was not to be discussed outside, even with family, much of their involvement can only be pieced together second-hand. Warren recalls the division of labour – Sear and Boswell worked on the encoder (Sear did the design and the conceptual thinking, Boswell constructed the unit), and Fraser designed the playback system[169] ('which was just as brilliant').[170] All three were 'enthusiastically'[171] involved in the design of the whole concept.[172]

Warren's original unit had used the volume of high-pitched 'beeps' to record instruments (if a beep was loud it meant the instrument was reading high, if soft, low). It was not very accurate. It recorded eight data channels at 4 per second with 5% uncertainty. EMI had tried using the pitch of the note to denote instrument readings, since then it wouldn't matter 'if there was a wobble in the wire'.[173] However, since the wire could change speed going through the 'spill', or could 'slip from one band slightly', the method also lacked accuracy. Coombes' ARL specification from 1959 called for 24 channels per second with much greater certainty. Sear was responsible for devising an improved encoding system for the recorder.[174] His idea was to use pulse count modulation: to put a note on at 3500 Hz, and count the number of 'wobbles' in the note. This technique was successful and provided only 1% uncertainty of readings.[175] He put the new electronics into a separate box to the wire recorder, so that, unlike the wire spools, there was no need for it to be designed to survive an accident.

Matters were made slightly awkward due to a personality clash between Warren and Rundle. There was 'a lot of antagonism' between the two 'for quite a long while'.[176] In March 1961, Warren and Sear flew to Salisbury, South Australia, to discuss manufacturing a unit in Australia with Armstrong-Whitworth Ltd.[177] Rundle was very annoyed. He wrote a memorandum to Coombes, Warren, and the Superintendents of Aerodynamics (C.E. Kerr) and Mechanical Engineering (Keeble), complaining that he had not been notified that Sear was going, and demanding that it be 'made clear to Warren that, the fact that this group is working on his project does not give him any authority over my staff.'[178] When Warren returned he agreed with one point - 'I heartily support your appeal for the position to be clarified as this atmosphere is hardly conducive

---

[166] Interview with Ken Fraser at AMRL, Fishermans Bend, September 11, 2001.

[167] Ibid.

[168] Ibid.

[169] Ken Fraser, 'Ground Station Equipment for Decoding the Recordings of a Flight Recorder', *Instruments Report 26*, Department of Supply, Australian Defence Scientific Service, Aeronautical Research Laboratories, Commonwealth of Australia, January 1968.

[170] Warren interview, above n 13.

[171] Interview with Ken Fraser, AMRL, Fishermans Bend, October 16, 2001.

[172] Warren interview, above n 13.

[173] Ibid.

[174] Fraser interview, above n 166.

[175] Ken Fraser, 'Addendum for the Technically Minded', in Fraser and Warren, 'The Black Box: An Australian Contribution to Air Safety', at
http://www.dsto.defence.gov.au/attachments/The%20Black%20Box.pdf
(Link updated by Ken Fraser on 19 Jan 2013).

[176] Ibid.

[177] D.R. Warren, 'Discussions with Armstrong-Whitworth Re; Flight Memory', Salisbury, South Australia, meeting on March 7, 1961, summary March 9, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[178] G.P. Rundle, memorandum to Warren etc, 'Re Crash Recorder Project', March 7, 1961. Archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

to the smooth running of a project…'[179] In a note to Coombes he requested a meeting 'of those connected with the project to resolve the present grievances and clarify the future programme.'[180]

Part of the difficulty with Rundle was what Warren had noticed earlier – 'It [is] hard to get anyone interested in your own idea, because he thinks it's your idea, it's not his…'[181] The corollary to this is that the person with the idea receives the accolades while those who make it work are often ignored.[182] The only surviving member of Rundle's team, Fraser, agrees – Rundle felt that Warren 'regarded it as his project, and just wanted the instrumentation guys to make something for him.'[183] Why had Rundle taken it on, then? Fraser supposes 'that, in spite of these reservations, Rundle did believe that innovative science was required, that he had the people who could meet the challenge, and that undertaking this work aligned with his charter.'[184]

Later, when in May 1963 Warren and Sear were to present a pre-production prototype of their work to Davall & Sons (and a 'large group of its potential customers') in the UK,[185] at the last minute Rundle stopped Sear from going with Warren.[186] Fraser was not allowed to go either, although he recalls being philosophical about it – 'I was pretty young at that stage. I was more concerned about "let's fly this damn thing, that's the real test" than the politics … as you get older politics tend to take over everything. At that age I thought it seemed like a pretty smart thing to be doing.'[187] An instrumentation person named Donald Cocks went with Warren instead, although he had not worked on the recorder.[188]

The ARL 'Flight Memory' now offered five advantages over competing recorders, as a press release sent to the ARL Head Office on December 20, 1961 outlined:

(a) It uses fine steel wire instead of plastic tape as a recording medium. This requires additional electronic apparatus to record both speech and data on the one wire, but greatly simplifies the problem of protecting the record against both fire and impact damage;
(b) The unit can record the readings of any desired number of instruments at a sampling rate of 24 per second. Recorders which rely on the engraving of metal foil for the data recording are usually limited to a small number of channels;
(c) The extremely light weight of the wire (a complete 4-hour record of speech and data weighs only 3 ounces…
(d) …Designed as a fully automatic device requiring no crew attention whatever…
(e) …May prove considerably smaller, lighter and less expensive than overseas units.[189]

---

[179] Warren, letter to Rundle, March 9, 1961, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[180] D.R. Warren, note to L.P. Coombes, March 9, 1961, archived in Warren, letter to Rundle, March 9, 1961, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[181] Warren, quoted in D.M. Walker, 'Inventor's black box records turbulent times', *The Age*, Business Section, September 7, 1998, p 1 at p 6.

[182] Fraser interview, October 16, above n 171.

[183] Fraser interview, September 11, above n 166.

[184] Fraser interview, October 16, above n 171.

[185] Letter from N.A. McKinnon, Physical Sciences Representative for Senior Representative, Australian High Commissioner, London, to L.P. Coombes, May 6, 1963, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

[186] Sear had organised a passport, at Warren's request, and had the immigration papers all signed and ready. The reason for the change may have been that Rundle had upcoming sick leave, and Sear was to replace him in charge of the Group when he was away. 'Statement re: recreation leave and sick leave for G.P. Rundle insofar as it has affected the duties of WFL Sear since October 1962', and various notes regarding passport preparation, etc, Sear family documents, used with permission of David Sear.

[187] Fraser interview, above n 166.

[188] Telegram from Secretary Supdep Melbourne to Secretary PM's Department, Canberra; Secretary Department of External Affairs; Department of Treasury and Public Service Board Canberra, May 13, 1963, p 3.

[189] 'The ARL "Flight Memory" Unit', Press release sent to H.O., December 20, 1961. Archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

The 'one and only'[190] flight test of the whole ARL system took place on March 15, 1962 on a DCA Fokker Friendship (VH-CAV) flying from Essendon Airport to Avalon.[191] Fraser remembers it as a 'critical' moment, and that the team were very pleasantly surprised to find that everything worked the first time – 'we recovered everything.'[192]

Government Makes Voice Recorders Mandatory (January 1963)

The Minister for Civil Aviation announced in March 1961, that 'technical developments enabled his department to require the installation of flight recorders in airlines… each recorder would have a device to erase all recordings of cockpit conversations at the conclusion of a successful flight' by January 1963.[193] Australia was the first country in the world to make CVRs mandatory. In the Melbourne Sun, Crofts stated that 'the [AFAP] was in favour of the principle of installing recorders in the cockpit of airliners'[194] (my italics). DCA outlined the requirement, based on the English OR/8003 but adding the need for 'flight station voice'[195] – it also applied only to 'turbine-powered aircraft' (as had the US one), which Rundle noted was strange – 'why single out only turbine-powered aircraft? This works against our device which was originally intended for all aircraft, even if small.'[196] Still, the requirement improved matters for the ARL recorder – a requirement would create an industry.

In September, however, the ARL team found themselves left behind. Ansett-ANA had convinced TAA to pool with it to purchase 70 units[197] of the American United Data Corporation (UDC)'s £2500 flight data and £1750 voice recorders.[198] The National Instrument Company (NIC), a subsidiary of Ansett-ANA, represented UDC in Australia, and although TAA had been interested in another recorder, they decided that 'the advantages of having the same type of flight recorder throughout Australia were considerable.[199]

The DCA has been regularly blamed for the domestic airlines choosing UDC ever since Keeble gave a lecture in 1981, after his retirement, on 'Research, Invention, Innovation and Technology Transfer' which claimed that 'the Department placed an order with an American firm to develop a unit complying with Australian specifications.'[200] This has since been repeated by writers such as Job.[201] Langford responds angrily that this was not the DCA's fault: 'We did NOT look to American Corporations for Australian recorders. Neither did we overlook or bypass the ARL recorder. We made the recorder mandatory. That is all… if the airlines decided to buy ARL recorders they were at liberty to do so.'[202]

---

[190] Fraser interview, above n 166.
[191] Fraser, 'Addendum for the Technically Minded', in Fraser and Warren, 'The Black Box: n Australian Contribution to Air Safety', above n 175. Unfortunately, there are conflicting records of when the flight actually took place – whether it was the 15th or the 23rd. The 15th seems most likely, as in a memorandum titled 're: "Flight Memory" tests 15/3/62" dated March 14, 1962, Coombes referred to 'the flight of CAV from Essendon to Avalon next Thursday.' Archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1953 to 1962, collated by David Warren and Kenneth Fraser. The 15th was a Thursday.
[192] Fraser interview, above n 166.
[193] 'Airlines to Install Recorders as New Safety Device', *The Age*, Thursday, March 9, 1961, p 9.
[194] 'Airliner Logs Will Go On "Tape" – Govt's Ruling', *The Melbourne Sun*, Thursday, March 9, 1961, p 15.
[195] Department of Civil Aviation, Section 103.10 'Aircraft Flight Recorders'
[196] G.P. Rundle, note to Coombs, Keeble and Warren, April 19, 1961, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.
[197] 'Orders for Flight Recorders Placed', *The Age*, Thursday, September 7, 1961.
[198] 'Device May Help Solve Air Crashes', *The Age*, June 19, 1962, p 4.
[199] Special Aviation Correspondent, 'Domestic Airlines Place Joint Order For Flight Recorders', *The Financial Review*, September 7, 1961, p 9.
[200] T.S. Keeble, 'Research, Innovation and Technology Transfer', the 1981 L.P. Coombes Lecture, delivered May 18, 1981, reprinted in *The Institute of Engineers, Australia, Mechanical Engineering Transactions*, 1981. Archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.
[201] Job, TIME article, above n 2, p 109.
[202] Langford email, above n 82. The first four sentences of this quote are in capital letters in his email, after the following: 'This is the last time I will ever say the following. I have said it so many times that I am sick of the

However, since the 'Flight Memory' system was ruled out by the DCA's original insistence on a separate voice channel for each of four microphones (which was possible with multitrack tape, but not with the wire recorder), regardless of the advantages that the ARL system offered, the fact that the airlines were 'free to choose' systems is not a complete answer.[203] Further, NIC had been enthusiastic about the 'Flight Memory' only a few months earlier. R. Hardy of NIC wrote to Coombes in April 1961 to suggest that NIC and Ansett-ANA 'contribute' to the ARL recorder;[204] ARL met with the NIC,[205] and matters were proceeding smoothly. At the meeting called by the DCA on the 24th, 'interest was expressed by a number of airline representatives, particularly Ansett-ANA, in the possibility of waiting till the advantages in cost and weight of the ARL unit could be assessed.'[206] However, the Director-General of the DCA countered this interest by saying that 'he did not expect it would be in commercial production by the fitment date' and then 'pointing out that the urgency of the situation would not permit a further extension of the fitment date.'[207] Perhaps ARL's leisurely reputation was more of an impediment than had previously been realised.

The confusion appears to have also arisen out of an error-filled transcript of a talk given by Warren in September 1963. A sentence delivered by him – 'DCA preferred to ask an American firm to develop a recorder to the anticipated American requirement, to fit in Australian aircraft' – was mistyped by the Department of Supply and promulgated to the DCA as 'DCA is preferring to ask an American firm to develop our recorder to anticipate the American requirements' – which meant quite the opposite.[208] Warren was rightly concerned that it implied that ARL thought 'that DCA scorned our design but then conspired with an American firm to build it' and that he had 'some bloated delusion of grandeur that all recorders were "his".'[209] There is no evidence that Warren ever made either of these statements; but the first one, in particular, stuck.

Canadian Tumbling Aerofoil Housing Unit (1962)

At Warren's first meeting with the Canadian NRC in 1958, they had proposed combining the wire recorder with their 'tumbling aerofoil beacon' device. This would be ejected from an aircraft just before a crash (during a sudden, unmanageably steep descent, for example) and use a radio beacon to make it, and the record it carried, easy to find. Throughout the stop-start ARL development, letters would arrive periodically for Warren from Canada asking whether progress was being made. In August 1962, Coombes finally wrote back to F.R. Thurston at the NRC to announce that, the unit being more fully developed ('this, unfortunately, has taken more time than we expected'), ARL was keen to reconsider the combination, and had arranged the spools on the Mirfield recorder so that they were now detachable from the rest of the unit.[210]

Unfortunately, in the meantime a Canadian company called Dominion Scientific Instruments Ltd (DSI) had developed a 'very nice' system providing 'voice, time, and 96 data channels … on ¼ inch tape.' NRC were still interested in seeing the ARL device, Thurston wrote, but it did 'on the surface appear to be a duplication

repetition. No-one on the ARL side of the problem will listen. I talked about it during almost the whole of a trip from America with Dr. Warren but it just does not seem to register.'

[203] David Warren, letter to Harnett, Davall & Sons, March 13, 1964, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

[204] R. Hardy, NIC, letter to Coombes, April 27, 1961, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[205] Keeble, handwritten note on Hardy letter, ibid, p 2.

[206] D.R. Warren, 'Report of Meeting called by DCA 24/4/61 to Discuss Crash Recorders', May 2, 1961, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[207] Ibid.

[208] D.R. Warren, note to L.P. Coombes on tape transcript of his comments, October 11, 1963, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[209] Ibid.

[210] Coombes, letter to Mr F.R. Thurston, NRC, August 15, 1962, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

of effort already in progress commercially.'[211] Coombes replied that 'news of the development in Canada of a lightweight recorder… is quite a surprise to us.' However, a launch system still seemed to be an asset for the ARL recorder, so he noted, 'we are nevertheless very keen to accept your offer to deploy our equipment for us in one of your tumbling aerofoils as we believe it may prove to have some advantages over the DSI model.'[212] Thurston agreed,[213] and a combined model was built in time for it to be displayed along with the ARL system at the International Trade Fair in Melbourne in February 1963.[214] When tested in 1964 (and sent out to Australia as a 'gift' from NRC)[215], 'examination of [the ARL] recorder showed no damage'[216] – the whole device worked.

Patenting the 'Flight Memory' (1954-63)

In 1958, Warren and Coombes had wanted to apply for a patent for the 'Flight Memory', believing that 'patent applications would certainly strengthen our position in negotiating with manufacturers.'[217] In March 1963, McDonough, Chief Commercial Officer, Planning Branch, Department of Supply summarised: 'it has been found impossible to get any effective patent protection, and the prospect of getting this in the future appears slim. In October 1958 ARL recommended the filing of a patent application. This was investigated carefully by our Patent Attorney, who advised that because of prior disclosure by ARL, particularly in an official report ARC.20, in his opinion there was no prospect of obtaining a valid patent.'[218] Since Warren had first suggested applying for a patent in March 1954, before he wrote TM-142 or ARC.20,[219] this would have been rather frustrating. McDonough noted that efforts to get the improved ARL 'Flight Memory' patented in March 1962 had met with similar difficulty. In May 1962, a meeting between Coombes, Keeble, Kerr, Warren, Sear, Fraser and Boswell had agreed that 'the system as a whole should be patented as soon as possible',[220] patent attorneys advised in July that only specific aspects of the circuitry and mechanical arrangements could be patented, at 'considerable' expense.[221]

[211] F.R. Thurston, letter to Coombes, August 28, 1962, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[212] Coombes, letter to Thurston, September 13, 1962, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[213] Thurston, letter to Coombes, October 4, 1962, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[214] The International Trade Fair took place in Melbourne between February 27 and March 16, 1963.

[215] Invoice from NRC Shipping Authority, undated, but October 1964, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

[216] Letter from H.T. Stevinson, NRC, to D.R. Warren, ARL, October 15, 1964, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

[217] Coombes 'Proposed Patent Application: Crash Recorder', letter to Controller, Research and Development, November 18, 1958, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[218] F.M. McDonough, internal memorandum to First Assistant Secretary (Policy and Co-ordination), Department of Supply, March 21, 1963, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

[219] Note attached to patent application for Crash Data Recorder, November 1958, above n 67.

[220] Ken Fraser, minutes of 'Inter-Divisional Meeting for Discussion of Crash Recorder Project', May 22, 1962, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[221] Clement Hack & Co, Patent Attorneys, Collins Street, Melbourne four page typewritten letter to F.M. McDonough, July 27, 1963, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

This, rather than 'bureaucratic ineptitude', is the main reason why Australia never made any money out of the 'black box'. To Warren's knowledge, 'it was all undertaken on a benefit of humanity charge.'[222] The ARL had always been open about what it was working on, a spirit which rarely rewards its adherents financially.

Davall & Sons and the 'Red Egg' (1963)

In March 1963, ARL received a serious commercial approach from Davall & Sons in the UK. Neil McKinnon of the Australian embassy had discussions with Davall[223] at which Davall met a 'flat payment' idea 'unenthusiastically', claiming that 'for other products they [had] made under licence … they [had] not made any initial payment… For this type of product, the risk is very high.'[224] He had to insist that, although 'transport of the prototype and data processor plus personnel is going to be expensive', it was 'absolutely essential.' Perhaps Davall could meet those costs instead of the flat payment. Mr V. Hunt of the Air Registration Board told McKinnon that 'there was no worry about the superfluous voice information capability. It was fairly certain to be made mandatory in a few years so we were a jump ahead provided it did not distort costs.'[225] McKinnon was still worried that Davall 'might not appreciate all the difficulties of modification and ultimately back out'[226], as EMI had before, although he had tried to worry them and failed: 'they apparently think they can sell this to the industry.'[227]

G. Krivocheef, the Managing Director of Davall, wrote to McKinnon on May 6, 1963, with terms for the production of the 'Flight Memory': Warren (for his reputation on the subject) and Sear (for his electronics expertise) would visit the UK (at ARL's expense) and stay 'at [Davall's] disposal' for four to six weeks; Davall would pay a total of £5000 for the rights to manufacture in the UK in addition to a royalty of 7½% on every unit made from the ARL Design. The device would be called the 'Davall – ARL Flight Recorder'.[228] Arrangements were made for Warren and Sear to go over in June (four weeks later, to McKinnon's concern – 'the time situation here is critical,' he wrote to Coombes)[229], then, because of Rundle, Sear was replaced by Cocks[230], so it was Warren and Cocks who arrived in the UK on June 11th, 1963 and spent the next month and a half with Davall.[231]

Davall wrote to ARL, thanking Warren and Cocks for their 'invaluable' services while in the UK, and commending 'the demonstrably high level of technical achievement of Messrs. Sear, Fraser and Boswell in the development of the electronics'[232]. Davall was extremely keen for either Sear or Fraser to work with

[222] Warren interview, above n 13.
[223] McKinnon letter, above n 185.
[224] McKinnon, 'Report on exploratory discussions with Mr V. French, Technical Sales Representative and Mr. A. Barnett, Technical Director of S. Davall & Sons Ltd, April 26, 1963, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.
[225] McKinnon, Report on discussions with Mr. V. Hunt of the Air Registration Board (UK), April 26, 1963, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.
[226] McKinnon, Report on exploratory discussions with Davall, above n 224.
[227] Ibid.
[228] McKinnon, letter to Coombes, May 3, 1963, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.
[229] McKinnon, letter to Coombes, May 6, 1963, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.
[230] This change was made by the 13th of May, see telegram from department of supply, above n 188, p 3.
[231] The itinerary of the trip (June 11-July 22, 1963), shows the Australians meeting with Davall, Bristol, BEA, BOAC, BUA, the Air Ministry (UK), AEE, Westland Aircraft, A.V.Roe, and English Electric Aviation. Itinerary archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.
[232] A.A.C. Barnett, Davall & Sons, letter to McKinnon, July 17, 1963, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

them for six months from October (although since they were only prepared to pay Fraser's more junior salary,[233] and were mainly interested in an engineer for producing the ground station, they clearly had Fraser in mind.)[234] The Secretary and Minister for the Department of Supply decided not to approve this[235], so Fraser remained behind – much to the annoyance of Coombes, who noted that an opportunity had been lost 'for giving Fraser extremely valuable experience at small cost'; and that the Department must have 'quite considerably incommoded' Davall's – 'I hope,' he wrote, 'that they were not too put out.'[236]

By the end of July, agreements and compromises on payment were apparently being finalised positively,[237] when an L.F. Bott, Acting Deputy Secretary at the Department of Supply, intervened.

> I am quite appalled at some of the teleprinters and other communications which seem to be flowing between ARL and Warren and McKinnon in London regarding the Flight Recorder. It seems to me that it is the responsibility of ARL to do the research and development and once we get to the stage where we are trying to find some commercial outlet for the product developed in the Laboratory, the responsibility for finding this outlet and carrying on negotiations is with the Chief Commercial Officer of this Office. I would request that you [Controller, R&D] inform ARL that any correspondence to London should be routed through the Chief Commercial Officer.[238]

This unnecessary bureaucratic intervention, from a division which had done nothing for the recorder, and now seemed to want to share in its success, seriously threatened relations with Davall (combined with the decision on Fraser above). The Department of Supply only wanted to give Davall the UK rights; Davall wanted an exclusive licence, at least temporarily, as they were already examining equipment in the USA and France[239] - so, the story goes, given the Department's hazy patent position, the company simply announced that it was going ahead anyway, 'effectively daring the Australians to take legal action'.[240] The department got nothing apart from a one-off payment to cover some ARL costs.

Davall's interest in contracting with ARL was, however, mainly killed by its failure to win a contract with the airline BEA for their recorders, losing to a company named Plessey, which used then-expensive computer decoders that were seen to have potential for refinement which the Davall-ARL recorder lacked.[241] Davall began work on the 'Plessey-Davall Flight Data Wire Recorder,' which was finished in February 1965.[242] Warren remained in friendly contact.[243]

When the next major aircraft crash occurred at London Airport in October 1965, the Plessey-Davall recorder was recovered from the wreckage.[244] Davall triumphantly advertised it as 'crash proven'[245] and promptly

[233] D.R. Warren, postcard to L.P. Coombes, August 10, 1963, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

[234] D.C. Cocks, 'Report on UK Visit to S. Davall & Sons by D.R. Warren & D.C. Cocks', August 8, 1963, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

[235] H.P. Matthews, Chief Scientist, Department of Supply, teleprint to McKinnon, October 1, 1963, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

[236] L.P. Coombes, letter to McKinnon, October 8, 1963.

[237] Senrep, Supdep, Australia House, London, teleprint to SupDep, Melbourne, Repeat; Coombes, July 23, 1963, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

[238] L.P. Bott, Acting Deputy Secretary, Department of Supply,

[239] Warren, teleprint to McDonough, August 15, 1963, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

[240] Maslen, above n 1, p 2.

[241] McKinnon, for E.L. Cook, letter to Secretary, Department of Supply, October 11, 1963, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 1: From 1953 to 1962, collated by David Warren and Kenneth Fraser.

[242] Davall 'Flight Data Wire Recorder', Progress Report, February 9, 1965.

[243] David Warren, letter to Harnett, above n 203.

[244] 'Air Crash – The "Little Black Box" could provide some answers', *County Times and Gazette*, Friday, November 5, 1965, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

developed the Series 1100 'Red Egg' (so-named because of its colour and shape – it was designed to 'bounce' free and roll away from a crash), which was released in 1967[246] and became widely-installed on BOAC and other aircraft around the world.

In Australia, meanwhile, an Ansett-ANA Viscount which crashed near Winton in Queensland in September 1966, had not carried a voice recorder, because the UDC recorders had such 'an extremely high failure rate' that the voice recorder requirement had been extended to beyond November 1966.[247] At the Board of Accident Inquiry, again chaired by Sir John Spicer, strong emphasis was placed on the 'not wholly satisfactory' performance of the recorders chosen by the airlines, or the regulation provided by the DCA. 'The Board is strongly of the opinion,' Spicer declared, 'that every effort should be made to obtain satisfactory recorders.'[248] A brief window appeared to arise for the wire recorders, but it was closed again at an informal meeting held in October. Langford announced that 'in view of the proven reliability of the foil recorders and the lesser available experience to date with wire recorders, there would be little incentive for operators to change over to the new system without other motivation.'[249]

In any case, it was no longer either Warren's or the ARL's problem. In December 1967, the Chief Superintendent of ARL advised Warren's team: 'It seems that you have achieved your object of informing DCA – as I see it, our role is complete.'[250] Their involvement was over. 'It had to be,' Warren notes, 'You've got to call it off at some stage.'[251]

[245] 'Crash Proven' advertisement for Davall, October 1965, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

[246] Advertising brochure for Davall 'Red Egg' Recycling Wire Crash Recorders, c 1967, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

[247] 'No "Voice Box" in Viscount', *The Age*, Friday, October 28, 1966, p 12.

[248] Spicer, J, Report of Chairman of Board of Accident Inquiry on Accident which occurred near Winton, in the State of Queensland, on the 22nd of September, 1966, to Viscount Aircraft VH-RMI, operated by Ansett Transport Industries (Operations) Pty Ltd, trading as Ansett-ANA, p 63. Archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

[249] D.R. Warren, minutes of informal meeting held at Aviation House, October 19, 1967, dated October 24, 1967, p 2. Apparently approved by Langford, in his letter to Coombes of February 12, 1968. Both of these are archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

[250] John L. Farrands, Chief Superintendent, ARL, note to D. Warren, December 8, 1967, on D.S. Graham, DCA, letter to John L. Farrands, ARL, November 27, 1967, archived in *Documents referring to the development of the 'Black Box' Voice-plus-Data Recorder by the Aeronautical Research Laboratories, Melbourne*, Volume 2: From 1963 Onwards, collated by David Warren and Kenneth Fraser.

[251] Warren interview, above n 13.

Conclusion

The 'black box' presents a difficult historical record. For one, Warren's recollections should be understood in the context that he has been interviewed on the subject many times since the mid-1980s, and that the events described throughout this thesis took place more than forty years in the past. For this reason, slight (but not substantive) discrepancies exist between various detailed recollections of long-past conversations. This is unfortunate for two particular reasons – firstly, many participants in these conversations are no longer alive, so care must be taken in quoting them second-hand; and secondly, because many are so filled with character that it is a pity that it is impossible to state with any certainty that they were originally so uttered. With the best of intentions, memory is still fallible.

Secondly, the documentary evidence of the two folders full of correspondence held by AMRL and the Australian Archives comprises only documents seen by people at ARL. Collated by Warren and Fraser for the AMRL's sixtieth anniversary celebrations in 1999, it is a rich source of primary historical evidence; but care must be taken not to depend solely on these records.

Further, there were many contributions to the development of the 'black box' by people whose names can no longer be recalled. When Warren first built a version of his device with valves, one of his young colleagues rebuilt it with the new transistor devices. In one sense, therefore, this person created the first version of the transistor-based 'Flight Memory'. Perhaps this gave the idea more credibility. However, it could probably have been done by anyone with electronics knowledge (this is Warren's justification for having forgotten the man's name).[252] One point about invention that Warren notes is that it is cumulative – inventors adapt previous ideas, they don't 'reinvent the wheel' each time. Warren did not invent all the technology, like the Minifon, required to make his device work.

Similarly, a question can be raised here about the ARL team – is their contribution more significant than, for example, that of the unnamed EMI team, or the engineers working later at Davall & Sons? The ARL team's work is significant because it was doing 'cutting-edge' research – it was not just developing a good idea, it was demonstrating that Australia possessed technical capabilities as good as those of any other country. (Which is why the 2001 Lawrence Hargrave Award names Fraser, Sear and Boswell along with Warren.) Their involvement is emphasised in this context.

In a more general form, there is a desire to link with heroes from the 'national family', which explains the patriotic tone of popular 'black box' history, noted in the Introduction. It also raises a problem. If national history is seen as national advertisement (Prime Minister John Howard condemning scholarship of matters the nation would rather forget as 'black armband' history), and is therefore not critical when evidence warrants it, how credible can it be? Much of the popular writing referred to in this thesis does not match up with the documentary record. This can partly be explained by an over-reliance on oral testimony – far easier for a newspaper journalist to simply interview Warren, who is a friendly and entertaining subject, than to piece together evidence from archive sources.

The oral evidence is problematic for the historian – it (a) can no longer be contradicted by the other parties, now dead, and (b) has evolved into a popular legend through repeated retelling. There is an unhelpful tendency in the literature to fit evidence into an assumed and easy story, of heroes and villains, 'goodies' and 'baddies'. The latter are those who simply did not immediately see the 'black box' as a 'great Australian invention' – but the difficulties Warren faced, as described throughout this thesis, were clearly systemic rather than personal. The simplistic story does disservice to all parties involved, including those painted as 'goodies'. A more balanced analysis, such as that intended here, can finally give the 'black box' narrative a genuine place in Australian historical writing.

---

[252] Ibid.

# Appendix - Images

Dr. David Warren.

c.1958

c.1999, with Minifon and ARL wire
recorder in asbestos and steel orange box.

February 1963 at the International Trade Fair in Melbourne, with the ARL Flight Memory unit. Warren is on the left. The curved device directly in front of him is the Canadian Tumbling Aerofoil design for ejecting the recording in an accident.
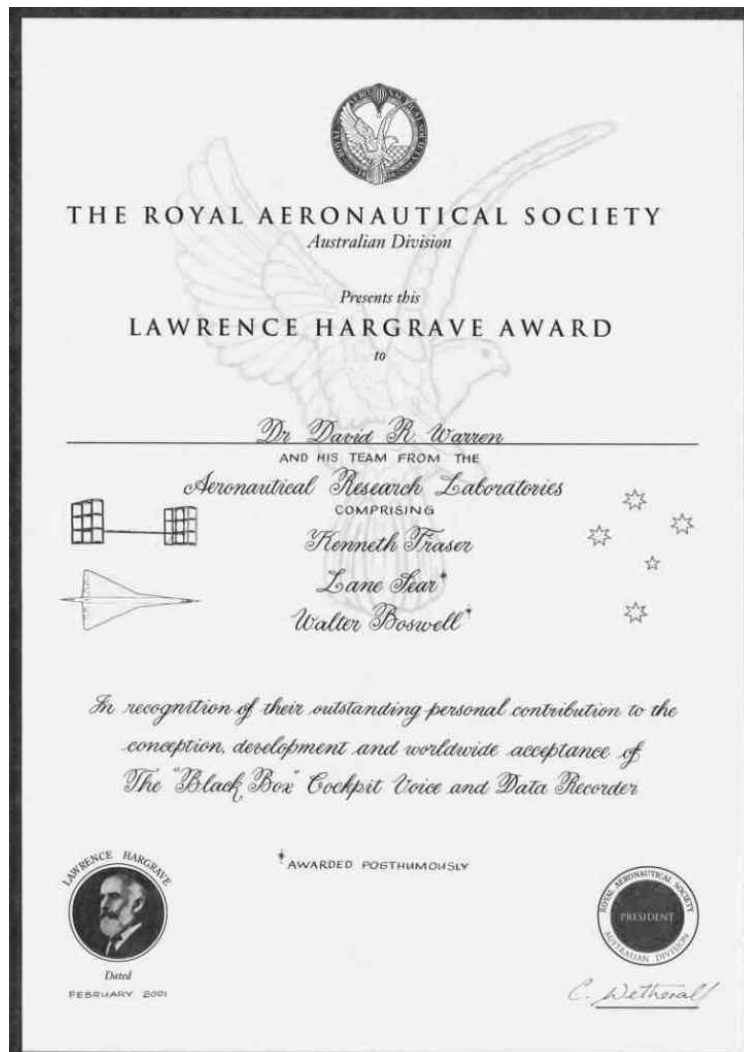
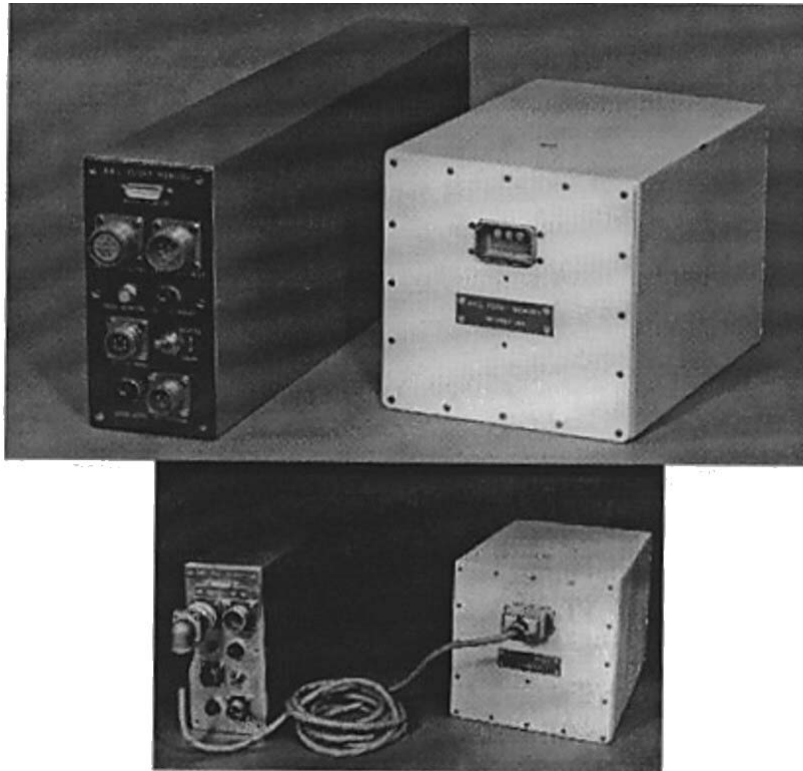**The ARL team.**
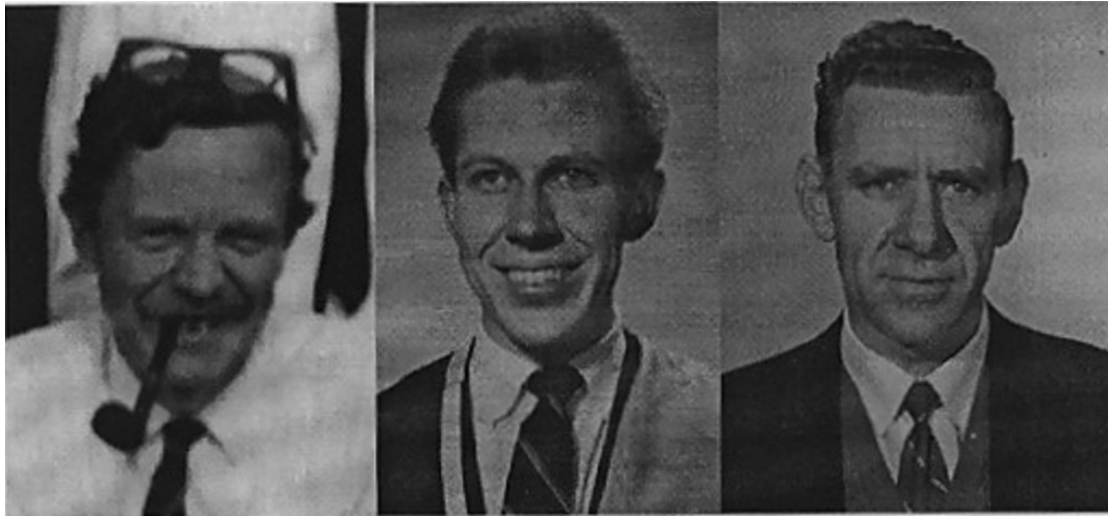
Lane Sear c.1964   Ken Fraser c.1959   Wally Boswell c.1961

The Royal Aeronautical Society Lawrence Hargrave Award, 2000.

The ARL Flight Memory unit (the 'black box').

Airborne elements – Lane Sear and Wally Boswell's encoding electronics on the left, and the actual wire recorder (as initially designed by Tych Mirfield) on the right. The latter was bright orange. These were connected as in the second photograph.

Ground elements – Ken Fraser's decoding station.

Bibliography

Primary Sources

'Interview with Dr David Warren, Scientist, On His Invention, The Black Box', *Morning with Jon Faine*, ABC 774 3LO, 20 February 2001, transcript by Media Monitors.

'Plane Safety Shock – Terrifying Time-Lag in Instruments', *Sunday Telegraph*, 15 May 1966.

Correspondence relating to cockpit voice recorders, held by Australian Federation of Airline Pilots, South Melbourne, used with permission of Mr Terence O'Connell.

Fraser, Ken F. 'Development of Digital and Analogue Systems of Decoding Pulse Width Modulated Data', *Instrument Report 25*, Aeronautical Research Laboratories, Australian Defence Scientific Service, Department of Supply, Commonwealth of Australia, January 1968.

Fraser, Ken F. 'Ground Station Equipment for Decoding the Recordings of a Flight Recorder', *Instruments Report 26*, Aeronautical Defence Laboratories, Australian Defence Scientific Service, Department of Supply, Commonwealth of Australia, January 1968.

Fraser, Ken F. 'Power Supply for the ARL Flight Memory Airborne Equipment', *Instruments Technical Memorandum 49*, Aeronautical Research Laboratories, Australian Defence Scientific Service, Department of Supply, Commonwealth of Australia.

Mirfield, T.N. and Warren, D.R. 'Miniature Wire Recording Decks with Limited Memory', *Australian Journal of Instrument Technology*, Society of Instrument Technology Australia, Vol XX, No 2, May 1964, pp 94-100.

The Age, 1957-2000.

The Herald Sun, 2000.

The Herald, 1958.

The Sun, 1957-1960.

Warren, David and Fraser, Ken. *Collection of documents (mainly correspondence) referring to the development of the "Black Box" Cockpit Voice plus Flight Data Recorder*, held by the Aeronautical Research Laboratories (ARL) Melbourne (predecessor of the Australian Defence Science and Technology Organisation (DSTO) Aeronautical and Maritime Research Laboratory (AMRL)), Volumes 1 and 2.

Warren, David R. 'A Comparison of the ARL Flight Memory System with the Current Australian Requirement for Aircraft Recorders', *Mechanical Engineering Technical Memorandum 240*, Aeronautical Research Laboratories, Australian Defence Scientific Service, Department of Supply, Commonwealth of Australia, May 1963.

Warren, David R. 'A Device for Assisting Investigation into Aircraft Accidents', *Mechanical Engineering Technical Memorandum 142*, Aeronautical Research Laboratories, Research & Development Branch, Department of Supply, Commonwealth of Australia, April 1954.

Warren, David R. 'Tests in the Development of a Crash Recorder', *Mechanical Engineering Technical Memorandum 180*, Aeronautical Research Laboratories, Research & Development Branch, Department of Supply, Commonwealth of Australia, April 1958.

Warren, David R. 'The ARL Flight Memory Project – A Brief Description of the Present System for Pre-Production Assessment', *Mechanical Engineering Report 105*, Aeronautical Research Laboratories, Australian Defence Scientific Service, Department of Supply, Commonwealth of Australia, October 1962.

Interviews

Bibo, Mr. John, 3 October 2001, via Telephone, half an hour, notes. (Bibo was Technical Services Manager of Ansett at the time and was present at the CAARC Council meetings in which Warren's idea was first discussed by authorities and industry).

Boswell, Mrs. Edna, 22 September 2001, Albert Park, one hour, notes. (Mrs. Boswell is Wally Boswell's widow. Boswell worked on the ARL Flight Memory unit with Fraser and Sear).

Ferrari, Mrs. Marie (née Welch), 4 October 2001, via Telephone, quarter of an hour, notes. (As Marie Welch she was Lane Sear's assistant when he was working on the ARL Flight Memory unit).

Fraser, Mr. Kenneth, 11 September 2001, Aeronautical and Maritime Research Laboratories, Fisherman's Bend, 2 hours, notes. (Fraser is the only surviving member of the ARL team).

Langford, Mr. Peter, 28 September 2001, via Email. (Langford was Head of the Airworthiness Branch of the DCA and was one of the principal correspondents between DCA and ARL during the duration of the project).

Schofield, Dr. Bill, 4 October 2001, Aeronautical and Maritime Research Laboratories, Fisherman's Bend, 1 hour, notes. (Schofield is the outgoing Head of AMRL, and worked under Warren in the late 1960s).

Warren, Mr. David, 29 August 2001, Caulfield, 2 hours, notes. (Warren is the originator of the ARL Flight Memory project).

Warren, Mr. David, 5 September 2001, Caulfield, 2 hours, notes.

Yeend, Mr. Frank, 1 October 2001, via Email (Yeend was in charge of the Operations Group investigating the Mackay accident and the principal witness at the subsequent Board of Accident Inquiry).

Secondary Sources

'Flight Memory "Black Box" Recorder, a) 1962 ARL Film 9 Mins b) 1992 Smithsonian Institute, Episode 15, Discovery Channel, 5 Mins', Video Cassette, VT No 3109, held by Aeronautical and Maritime Research Laboratory, Defence Science and Technology Organisation, Department of Defence.

Aeronautical Research Laboratories, 1939-1979, Aeronautical Research Laboratories, Fishermans Bend, Melbourne, October 1979.

David Thelen, *Memory and American History*, Indiana University Press, Bloomington, 1990.

Graham Little, *Speaking for Myself – Interviews with Notable Australians*, McPhee Gribble, Melbourne, 1989.

Ian Donaldson, Peter Read and James Walter (eds), *Shaping Lives – Reflections on Biography*, Highland Press, Queanbeyan, 1992.

Job, Macarthur. 'Long Overdue Recognition For "Black Box" Pioneer', *Australian Aviation*, March 2001, pp 40-42.

Job, Macarthur. *Air Disaster*, Volume 1, Aerospace Publications, Canberra, 1994.

Paula Hamilton, 'The Knife Edge: Debates about Memory and History', in Kate Darian-Smith and Paula Hamilton, eds, *Memory and History in Twentieth-Century Australia*, Oxford University Press, Melbourne, 1994, pp9-32.

Schofield, Dr W.H. 'Australian Research and Development for Military Aviation – Past, Present and Future', Eleventh Dr Henry K. Millicer Lecture, 16 October 2001.

Schofield, Dr W.H. 'Sixty Years of Aeronautical Research at Fishermans Bend', 26th Annual L.P. Coombes Lecture, 27 September 1999.

The Leading Edge – Sixty Years of Aeronautical Research & Development for Australia's Defence, 1939-1999, Aeronautical & Maritime Research Laboratory, Defence Science & Technology Organisation, Fishermans Bend, Melbourne, 1999.

Walby, Basil J. 'Two Australian Black Boxes: Institutions and Innovation', MSc, University of Melbourne, 1993.

Warren, David and Fraser, Ken. 'The Black Box: An Australian Contribution to Air Safety', Defence Science and Technology Organisation,
http://www.dsto.defence.gov.au/attachments/The%20Black%20Box.pdf,, (link updated by Ken Fraser on 19 Jan 2013).