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AERONAUTICAL RESEARCH LABORATORY

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General Document 37

AIRCRAFT ACCIDENT INVESTIGATION AT ARL
THE FIRST 50 YEARS

by

J.L. KEPERT

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SUMMARY

Early Australian experience with the investigation of aircraft accidents is covered briefly as a prelude to the foundation of the Aeronautical Research Laboratory. With its foundation, a more scientific approach was possible. ARL was quickly involved with accident investigation, an activity which has been maintained throughout its fifty year history. This report examines ARL experiences during those fifty years with the idea of providing some useful guidelines for the next half-century.

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NZ Aerospace CT-4 Airtrainer A19-028 crashed at Oakey, Queensland on 16 August 1979 killing the crew of two. From an inspection of the ground impact markings, it was determined that the aircraft had been diving at 25° with 10° of starboard bank when initial ground impact occurred. Following this impact, the aircraft bounced and finally came to rest during a second heavy impact. A thorough examination of the wreckage disclosed no evidence of any pre-crash defect, all control surfaces and control runs were intact at ground impact, and it was concluded that the aircraft flew into the ground because of the pilot's inattention to his flight path. Despite the fact that the cockpit structure survived relatively intact, Fig. 58, this accident was considered non-survivable because of the large vertical accelerations experienced.

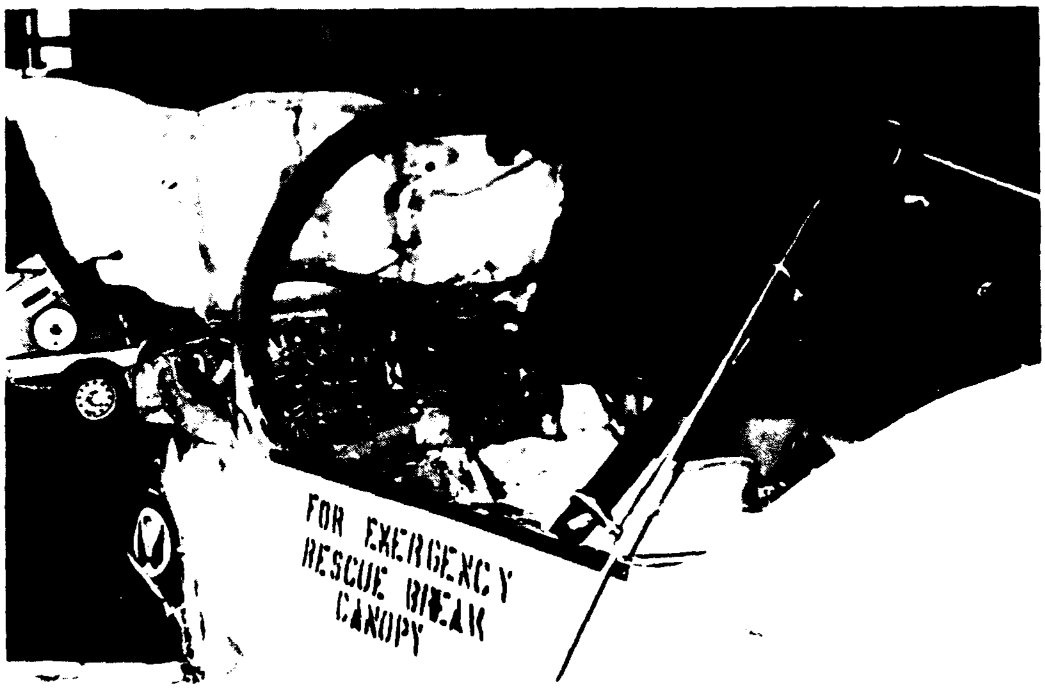

Fig. 58 Cockpit structure of A19-028 after the accident. Note the impact damage to the instrument panel and the missing windscreen

However, both occupants received fatal injuries when they were thrown through the windscreen. This should not have happened. A close examination of their safety harnesses revealed that these had been fitted properly, inertia reels had locked correctly, and the harnesses had not failed through overload. Instead, the quick release buckles had distorted during the initial impact and then unlocked during the subsequent rebound allowing the occupants to be ejected during the second heavy impact. This accident accelerated ARL research into pilot restraint systems with particular attention being given to improved designs of quick release buckles.

Another way of stacking the cards is to impose an excessive work load on the pilot and the work load is never higher than when making a night landing aboard an aircraft carrier at sea. The point is illustrated by the accident to Grumman Tracker N12-153608 which crashed while attempting a night landing aboard HMAS *Melbourne* on 10 February 1975. The investigation of this accident was a novel experience for ARL; the request for assistance was received from the RAN more than 12 months after the accident, there was no wreckage to examine, and the investigation was, perforce, based solely on written statements by eyewitnesses.

Tracker N12-153608 was catapulted from the carrier at 2200 hours on 9 February 1975 to carry out an anti-submarine warfare close support task. The night was unusually dark with no visible horizon so that approximately three hours of the flight were spent in Instrument Meteorological Conditions (IMC). At 0323 hours the following morning, the aircraft attempted a routine landing using the mirror landing system as an approach aid. In the days preceding the accident, the mirror setting had been changed from an approach slope of 4° to 4.5° but the pilot had not been informed of this. In consequence, the approach was slightly high and fast, the aircraft failed to pick up an arrester wire, an event known as a "bolter", and it subsequently crashed into the sea approximately ten seconds later. All four crew members managed to escape from the sinking aircraft and were rescued uninjured.

On receiving a bolter call from the Landing Safety Officer, standard procedure was for the pilot to open the throttles to full power and to establish a positive pitch up attitude, then to select undercarriage up while the Tactical Co-ordinator (Tacco) in the right hand seat raised the flaps from full to $^2/_3$ down. One difficulty with this procedure was the need to monitor the engine instruments closely to avoid exceeding the maximum permissible boost pressure of 57 inches Hg. Since the Tracker engines were not fitted with automatic overboost protection devices, this requirement imposed an additional work load on the pilot at a critical time. According to both the pilot and Tacco, full power was achieved with the vertical gyro indicator (VGI) showing a positive pitch up attitude of 5° as the aircraft left the flight deck. The RAN Board of Inquiry accepted this evidence and concluded that the failure of the aircraft to climb away successfully resulted from an inadvertent selection of zero flap by the Tacco.

Subsequent flight trials showed that, under the accident conditions of 87 KIAS and 22,000 lb aircraft weight, the Tracker had such a large performance reserve that it could climb away at any positive pitch angle from zero to 7.5° regardless of flap position. Faced with this evidence, the Board of Inquiry withdrew its earlier findings and requested further investigation.

ARL began its investigation by noting that the Tracker had provision for two modes of flap operation. In the normal retraction mode, an orifice in the hydraulic circuit restricted the flow to limit the rate of flap retraction. The size of the orifice was apparently selected to provide a flap retraction rate that optimised the initial climb performance of the aircraft. That is, the flap retraction rate was matched to the usual acceleration. Selection of zero flap would therefore result in better aircraft performance than the selection of $^2/_3$ flap as required by standard operating procedures. This was confirmed by flight trials. In the fast retraction mode, which required the aircraft to be supported by the undercarriage, the orifice was bypassed to allow fast retraction.

Having eliminated flap operation as the cause of the accident, only two possible alternatives could be postulated, viz. loss of power and incorrect pitch attitude. Both the pilot and Tacco stated that full power was applied and maintained. Some external witnesses were less certain but none suggested that the sound of the engines had varied considerably to indicate a substantial loss of power. Again, flight trials showed a large power reserve such that satisfactory climb performance could still be achieved with boost pressures reducing rapidly to 42 inches Hg. There was a consistent thread running through the statements by external witnesses that the aircraft attitude was flatter than normal with estimates ranging from level to slightly nose down, e.g. 'definitely not a climbing attitude at any stage'. Even the Tacco and one of the crewmen in the rear of the aircraft sensed that the attitude was abnormally flat. Yet both the pilot and Tacco were adamant that the VGI was registering 5° nose up.

To human factors experts at ARL, this accident had all the hallmarks of the "dark night take-off accident". This term is used to describe an accident which results from the failure to establish a positive rate of climb following take-off in conditions which deprive the pilot of external visual cues. In this situation, the pilot senses a push in the back but is unable to distinguish between the forces resulting from linear acceleration and gravity. Hence, horizontal acceleration is easily misinterpreted as a pitch up attitude (somatogravic illusion). Under these conditions, it is vital for the pilot to monitor his flight instruments closely, particularly with respect to pitch attitude and rate of climb. This is all very well but the instruments must be read correctly. If the pilot is suffering from disorientation, there is a strong tendency to see what ought to be there rather than what is actually there.

Spatial disorientation implies a false perception of attitude and motion. The four conditions which lead to its onset were all present in the case in question, viz:

a. a state of anxiety or mental arousal prevalent for some minutes prior to the event,

b. control of the aircraft had involved a motor task of one or both hands,

c. immediately prior to the event, the pilot had been distracted from the immediate task of controlling the aircraft attitude,

d. horizontal acceleration had rotated the apparent gravity vector.

Certainly in the period preceding the accident, the pilot was highly aroused on the mirror approach and had been manually controlling the aircraft; the bolter situation, bolter call and undercarriage actions provided a distraction from the attitude control task and the horizontal velocity was changing.

Applied Report 78 concluded that the most probable cause of the accident was that the pilot was affected by unrecognised disorientation associated with somatogravic illusion and flew the aircraft into the sea. Factors thought to have contributed were:

a. the exceptionally dark night,

b. the pilot's unawareness of the change of settings to the mirror landing aid,

c. the pilot's lack of any previous bolter experience,

d. the need to monitor engine instruments instead of the VGI as the aircraft was rotated.

The VGI readings stated to have been present during the overshoot probably were incorrectly perceived because of the visual disturbances and mental confusion characteristically associated with disorientation episodes.

Finally, a word about collisions. Over the years, ARL has been involved in the investigation of a number of in-flight collisions and that between DH Dove VH-WST and Piper Twin Comanche VH-WWB over Bankstown, NSW on 13 March 1974 is a typical example. These two aircraft flew slowly converging courses for over one minute before they collided wing tip to wing tip and broke up in flight. None of the four occupants survived. The investigations usually centre around two questions; why did the pilots fail to see each other in time to avoid the collision and, if appropriate, why did they fail to eject successfully? These questions can frequently be answered provided the exact collision geometry is established and this is ARL's function. In performing this function, it is necessary to seek the unique solution which satisfies all of the in-flight damage. Any solution which discards some of this damage as intractable, cannot be right.

A case in point is provided by two Douglas Skyhawks of the RAN which collided in flight at Nowra, NSW on 17 July 1975. The contact was gentle, inflicting only minor damage on the two aircraft, to the extent that the pilot of N13-155051 was able to land without undue difficulty. However, N13-155055 crashed and the pilot was killed. Once ARL established the exact collision geometry, it became clear that the latter pilot must have suffered incapacitating head injuries during the collision and his failure to land, or eject successfully, was thus explained. The point is illustrated more fully in the following description of the collision between two F/A-18 aircraft near Tindal, NT on 2 August 1990.

The two aircraft were practising a simulated pairs intercept. In this exercise, two aircraft track an electronically generated radar return presented on their head-up displays. The aircraft manoeuvre until one achieves parameters which satisfy missile launch requirements. Missile launch is simulated and the launching aircraft continues to provide radar illumination of the simulated target throughout the computed missile flight time. Aircraft manoeuvres are quite violent throughout the interception and a high degree of teamwork is required.

Head-up displays are recorded on videotape during the exercise. An inspection of the tape from A21-29 showed that the aircraft was pulling about 3.3g in a 90° banked turn to starboard, Mach 0.86, altitude 32,000 ft, when it collided with A21-42. During the collision, A21-29 lost most of its port wing outboard of the wing fold, Fig. 59, and a 2 ft section of its port tailplane was removed. Control was retained and the aircraft landed successfully. The pilot of A21-42 was killed in the accident; his aircraft crashed and was totally destroyed.