



# SIFTING THROUGH THE EVIDENCE

RAAF F-111 and AF/A-18 aircraft and crew losses

An aviation safety magazine of the Australian Defence Force



# List of abbreviations

ACAUST	Air Commander Australia	kt	knot
ACC	air conditioning control	LARA	low altitude radar altimeter
ACG	Air Combat Group	LEPL	low equipment pressure caution lamp
ACT	air combat tactics	LSALT	lowest safe altitude
ADF	Australian Defence Force	MSA	minimum safe altitude
ADI	attitude display indicator	MSDRS	maintenance signal and data recording system
AGL	above ground level	nm	nautical miles
AIF	Aircrew Information Folder	ODWS	oxygen delivery warning system
AIP	Aircrew Information Publication	QFI	qualified flying instructor
AIT	Accident Investigation Team	RADALT	radar altimeter
AMSL	above mean sea level	RAG	runway arrestor gear
ASL	above sea level	RCR	runway condition reading
ASSK	air source selector knob	RNZAF	Royal New Zealand Air Force
ATC	air traffic control	RSO	Range Safety Officer
AVMED	aviation medicine	RWY	runway
AVRM	aviation risk management	SAR	search and rescue
BIRT	bird impact resistant transparencies	SATG	Student Air Training Guide
BOI	Board of Inquiry	SCP	set clearance plane
CAS	Chief of Air Staff	SMO	Senior Medical Officer
Cat	category	SOPs	standard operating procedures
CATSCHEME	categorisation scheme	SRA	start roll altitude
CFIT	controlled flight into terrain	SRG	Strike Reconnaissance Group (now defunct and part of ACG)
CRM	crew resource management	SWBTA	Shoalwater Bay Training Area
DDAIFS	Directorate of Defence Aviation and Air Force Safety	TACPROCs	Tactical Procedures Manual
DDI	digital data indicator	TF	terrain following
DSTO	Defence Science and Technology Organisation	TFC	Training Flight Commander
ECS	environmental cooling system (F-111)	TFG	Tactical Fighter Group (now defunct and part of ACG)
ECS	environmental control system (AF/A-18)	TFR	terrain following radar
EPR	exhaust pressure ratio	TSA	target safe altitude
FEHL	forward equipment hot caution lamp	TTG	time-to-go
FHT	final handling test	TTI	time-to-impact
FIC	Fighter Introductory Course	USAF	United States Air Force
GCA	ground controlled approaches	VAD	vital area defence
G-LOC	G-induced loss of consciousness	VFR	visual flight rules
HSOPs	Hornet Standard Operating Procedures	VMC	visual meteorological conditions
IADS	Integrated Air Defence System	WSPD	weapons systems performance document
IMC	instrument meteorological conditions	WWHL	wheel-well hot caution lamp
INS	inertial navigation system	20CU	Number 2 Operational Conversion Unit
IP	initial point		
KIAS	knots indicated air speed		



# CONTENTS

2	List of abbreviations
4	Foreword
6	Armidale, 28 April 1977, F-111C A8-136
8	Evans Head, 29 September 1977, F-111C A8-133
10	Auckland, 25 October 1978, F-111C A8-141
12	Ohakea, 24 August 1979, F-111C A8-137
16	Moruya, 28 January 1986, F-111C A8-139
18	Tenterfield, 02 April 1987, F-111C A8-128
22	Guyra, 13 September 1993, F-111C A8-127
24	Aur Island, 18 April 1999, F-111G A8-291
28	Great Palm Island, 18 November 1987, AF/A-18 A21-104
31	Tindal, 02 August 1990, AF/A-18 A21-42
34	Tindal, 05 June 1991, AF/A-18 A21-41
38	Shoalwater Bay, 19 May 1992, AF/A-18 A21-106
40	Summary
42	Conclusion

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# FOREWORD

This document is not a vehicle for the apportioning of blame. The candid responses of numerous witnesses and personnel involved in these accidents were a major factor in the identification of many significant events leading to these accidents. This document is published for the education of those connected with ADF flying operations. The sole purpose of that education – the dissemination of the lessons learnt from the experiences of others – is to enhance flying safety and prevent future accidents of a like nature. All of the witnesses and personnel involved, by their co-operation in the subsequent inquiries, contributed in great measure to the goals of flying safety. DDAAFS trusts that the reader will treat the information contained herein in the same spirit as it was given.

“What’s the hurry?  
Are you afraid I won’t  
come back?”

*The Red Baron, Manfred von Richthofen’s  
last recorded words in reply to a  
request for an autograph  
as he was climbing into  
the cockpit of his aircraft.*

**T**he F-111 has provided Australia’s air strike capability since 1972. Of the 28 F/RF-111C<sup>1</sup> and 15 F-111G eventually acquired, eight aircraft have been lost, with 10 aircrew killed. Australia’s 75 AF/A-18 fighter aircraft have been in service since 1985. The four AF/A-18 aircraft losses to date have all been fatal, with the loss of five lives.

The following articles examine these F-111 and AF/A-18 accidents.<sup>2</sup> By looking at the circumstances the crew

found themselves in, reviewing Board of Inquiry (BOI) findings,<sup>3</sup> and determining what has (or hasn’t) changed as a result of these accidents, may help today’s aircrew and supervisors prevent similar occurrences. In no way is this publication meant to criticise the actions of individuals involved. Most aircrew in similar circumstances would likely have not been able to change the outcome that these competent and mostly experienced professional aviators found themselves in.<sup>4</sup>

As noted by the BOI for the last F-111 accident, the majority of aircraft accidents result from, not a single catastrophic event, but a chain of events that successively and cumulatively create conditions and environments in which an accident becomes the inevitable outcome. An accident is usually the result of a sequence of aggregating events. It has also been found that the interruption of that sequence at any point, through error identification and remedial action(s), is sufficient to terminate the degenerative path and re-establish the profile for the successful and safe completion of the mission.

The ADF espouses the widely accepted Reason accident causation model for investigation of ADF aviation accidents. Central to Reason’s approach is the concept of the organisational accident, in which latent conditions, arising mainly in the managerial and organisational spheres, combine adversely with local triggering events and with the active failures of individuals at the sharp end. According to Reason, there are four common elements in most accident chains:

**Organisational or latent conditions.** These conditions are managerial policies and actions within one or more organisations. Their effects are not immediately apparent and may lie dormant for a considerable time. Examples include deficient policies or orders, inaction/slowness in remedying shortfalls with standard procedures or documentation, resource cut-backs, or acceptance of low staff numbers or experience levels without a commensurate reduction in tempo or expected output.

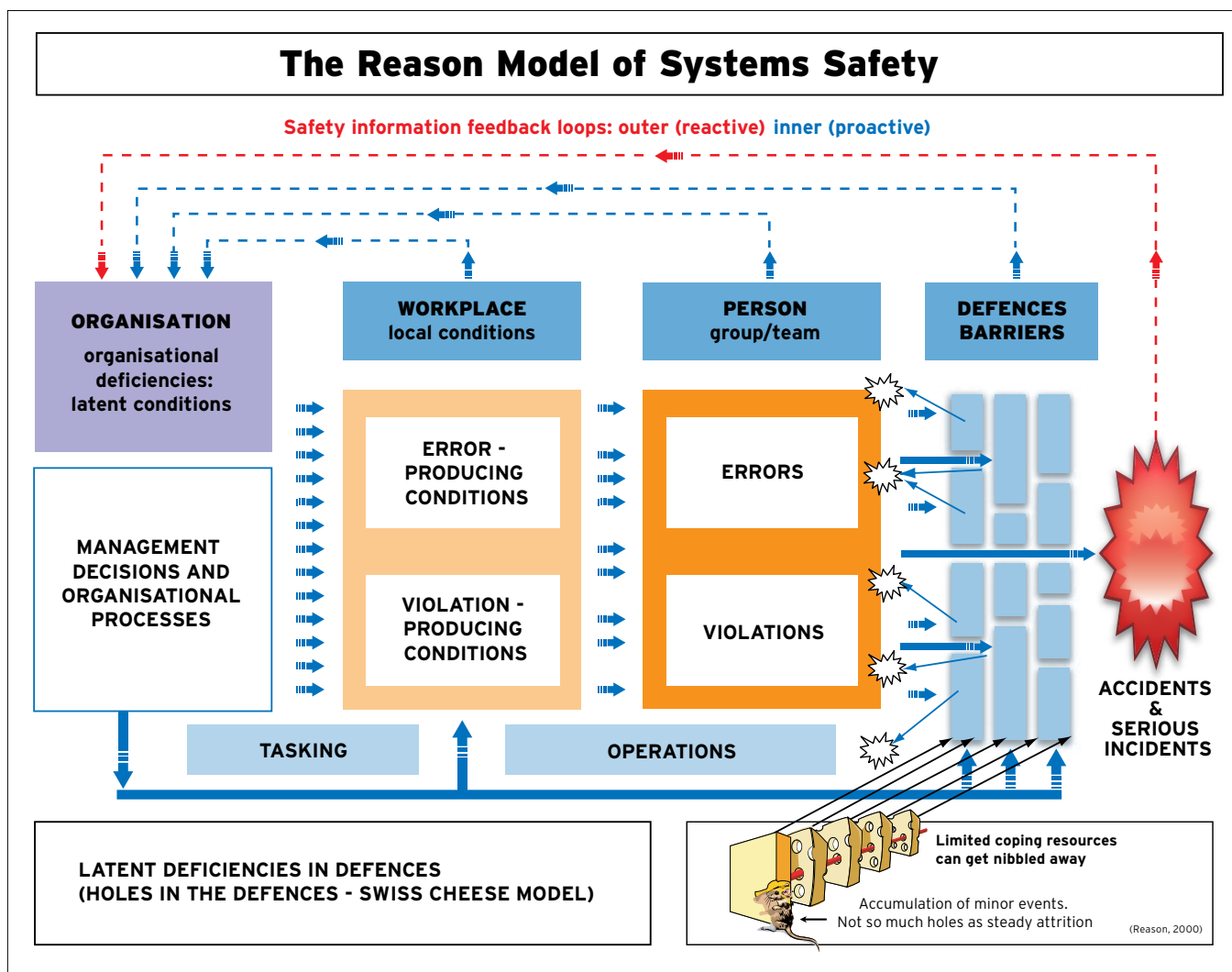
**Local (workplace) factors.** These are conditions that can affect the occurrence of active failures (errors and violations) and include such things as task,

1. Australia initially purchased 24 F-111C aircraft, which were supplemented with four attrition aircraft in 1982.

2. The ADF SAFETYMAN, Vol 3, Pt 1 defines an aircraft accident as an occurrence that results in death or serious injury to any person; loss of an aircraft, or an aircraft being missing or inaccessible; or damage to or structural failure of an aircraft which adversely affects the structural strength, performance or flying characteristics of the aircraft and would normally require major repair or replacement of the affected components.

3. There was no BOI formed for the accident of F-111 A8-127. Accordingly, available information is limited to the Accident Investigation Team (AIT) report.

4. In two of the accidents, the trailing aircraft was only made aware of the terrain hazard as a result of the fireball from the accident aircraft’s ground impact.



Above: The organisational accident.

situational or environmental factors. Examples include task unsuitability requiring adoption of workaround procedures, (for example simulation of employment of weapon types not intrinsic in the aircraft system), low crew experience or currency, or marginal weather conditions.

**Active failures.** These are errors or violations (unsafe acts) that have an immediate adverse effect. These unsafe acts are typically associated with operational personnel. Examples include inadequate mission preparation, poor division of workload between the crew, or not utilising all available systems or measures for terrain clearance.

**Inadequate or absent defences.** Defences identify and protect against technical and human failures arising from the previous

elements. Examples include deficient supervision, deficient procedures, or lack of guidance (for example guidance on how crews should react to system cues that may affect aircraft safety such as altitude low warnings).

The following accidents can likewise be attributed to these four elements whose influences, to varying degrees, were contributory to the final outcome.

Squadron Leader Bill Savill  
Air Safety Investigator  
Royal Australian Air Force

# Inflight fire and ejection near Armidale, 28 April 1977, (F-111C A8-136)

**D**uring an emergency diversion following a right engine oil hot indication, the aircraft suffered a severe internal explosion.

The engine throttles jammed in their selected position, the right engine fire light illuminated and could not be extinguished, and shortly thereafter the pilot could not retain control of the aircraft.

An ejection was initiated and the aircraft crashed 14 nm north of Armidale, NSW. The ejection was successful, with the crew suffering minor injuries as a result of crew module ground impact forces.

The incident crew were conducting a day single-ship sortie that was to include maritime operations, automatic terrain following (TF) flight, simulated landstrike target attacks and practice bombing at Evans Head air weapons range.

## Crew

Pilot: Cat B – 2493.2 hrs total time/1624.6 hrs F-111; current (USAF Exchange Officer)

Navigator: Cat C – 4662.4 hrs total time/292.7 hrs F-111; current

## Accident summary

During the approach to the second landstrike target with military (non-afterburner) power selected, the right engine oil hot caution lamp illuminated. The pilot immediately retarded the right throttle to idle.

In accordance with the extant checklist procedures, the pilot then advanced the right

throttle into minimum afterburner (Zone 2)<sup>5</sup> to enhance engine oil cooling. The caution lamp immediately went out.

The pilot decided to divert to Amberley rather than Williamtown (the aircraft was approximately 70 nm northwest of Williamtown) as the checklist actions appeared to work and the flight time difference was only 10 minutes.

During the climbing turn back to Amberley the pilot deselected afterburner. Ten seconds later the right engine oil hot caution lamp illuminated for a second time, and was again extinguished by advancing the throttle into afterburner.

The crew discussed shutting down the engine, but decided against it as all other engine indications were normal. Twice more, the caution lamp illuminated approximately 10 seconds after selection of military power and was able to be extinguished with reselection of afterburner. With afterburner selected, the caution lamp again illuminated and the pilot had to advance the throttle to Zone 4 to extinguish the light. Approximately 30 seconds later the crew heard and felt a loud explosion (14 minutes after the initial engine oil hot indication).

The pilot attempted to close the right throttle but could not move either throttle. The pilot then noticed that the landing gear warning lamp and right engine fire warning lamp were illuminated. The right engine fire warning pushbutton was depressed, which extinguished the light.<sup>6</sup> The pilot then tried to force the right throttle closed but both

throttles were locked solid. The right engine fire warning lamp illuminated a second time at which time the pilot actuated the agent discharge switch but the fire light remained on.

A mayday was declared and a decision to divert to the nearest suitable airfield (Coffs Harbour) was made. The aircraft then commenced an uncommanded roll to the right that quickly developed into a hard yaw to the right. The pilot was unable to regain control so he initiated ejection at an altitude of 9000 ft AMSL. During the descent, the pilot noticed that the right side of the aircraft was enveloped in fire.

Wreckage analysis, including that collected seven miles short of the aircraft ground impact point, indicated that the inflight explosion blew off the upper surface of the rear left-hand saddle fuel tank and also probably ruptured the forward main fuel tank.

## Board findings

The Board made the following findings:

1. The primary cause of the accident was attributed to an undetermined technical defect or defects (probably a mechanical component within the right-hand engine nacelle).
2. The most probable cause of the accident was considered to be an engine bleed air duct failure.<sup>7</sup>
3. The secondary cause of the accident was an internal, rear-fuselage explosion which caused fire, structural damage and loss of control.

5. Zone 5 is maximum afterburner power in the F-111.

6. Depressing either of the two F-111 engine fire warning pushbuttons closes the engine fuel shutoff valve, the utility and primary hydraulic shutoff valves for the respective engine, and arms the extinguishing agent discharge switch to that engine. The agent discharge switch must be held to the AGENT DISCH position to activate the one-shot extinguishing agent.

7. The BOI noted a deficient maintenance practice, discovered one month after the accident, could have caused similar outcomes as experienced by the incident crew. During a routine servicing of an F-111 aircraft it was found that the right-hand engine nacelle heat shields were improperly installed. An inspection of the F-111 fleet revealed four separate cases of incorrectly installed engine nacelle heat shields, including one case of complete omission of a section of heat shielding. Had this not been discovered it is probable that the flailing heat shield (caused by nacelle cooling airflow) would have penetrated the 16th stage bleed duct, which would have disintegrated the heat shield with the high pressure/temperature bleed air impinging directly on to the exposed aft fuel tank side wall.



4. The crew acted in accordance with published flight manual and checklist procedures.
5. The extant F-111C flight-manual procedures for engine oil hot occurrences were found to be deficient as it did not provide for occurrences other than as a result of power reductions during periods of aerodynamic heating caused by supersonic flight.
6. There was no formal administration process for the receipt, control and actioning of USAF F-111 Safety of Flight Supplements received by Headquarters Support Command. Additionally, these supplements did not include reasoning for the change, therefore further clarification

was often sought from the USAF before deciding whether the change was applicable to RAAF F-111C operations.

*(Author's note: A supplement relating to cautionary oil hot procedures during steady state (subsonic flight) conditions had been received prior to the accident; however, further information was being followed up with the USAF. Had the change been introduced, the incident crew probably would have acted on the new information and shut down the engine after illumination of the oil hot light.)*

## Recommendations

Board recommendations included:

1. The USAF F-111 modification for 'Improved Fire Detection System' be installed on RAAF F-111C as a matter of urgency.

2. Introduction of formal procedures for the rapid handling of flight manual and Safety of Flight Supplement changes received from the USAF.

## Changes attributable to this accident

Changes to F-111 procedures and aircraft modifications that were more than likely influenced by this accident included further amendment of the checklist actions for F-111 engine oil hot caution lamp illumination, to include actions to retard the throttle of the affected engine to idle and to close the engine bleed air shut-off valves.

Below: Wreckage site 14 nm north of Armadale – aircraft A8-136.



# Birdstrike and ejection near Evans Head, 29 September 1977, (F-111C A8-133)

**D**uring the downwind leg at 2000 ft AMSL for a second bombing pass on a 320° attack heading, the aircraft experienced at least three birdstrikes on the cockpit transparencies.

Between 10 and 12 seconds later ejection was initiated at a height of 720 ft AMSL and airspeed of 520 kts. The crew module impacted the ground after a flight time of approximately three seconds. Both crew members were killed. The aircraft crashed into the ground approximately 9 nm south-southwest from the main radar target at Evans Head air weapons range (NSW) and caused an extensive ground fire. Wreckage from the windscreen panels and other cockpit contents were recovered 1.5 nm back along the flight path from the aircraft's ground impact point.

The incident crew were conducting a day single-ship sortie, which was the first flight of the operational phase of the F-111C Operational Conversion Course and was to include automatic TF flight, maritime operations and practice bombing at Evans Head air weapons range. The sortie was the student pilot's first bombing mission. The right seat was occupied by a 6SQN Training Flight qualified flying instructor (QFI) pilot.

## Crew

Pilot: Cat U<sup>8</sup> – 3341.7 hrs total time/17 hrs F-111; (F-111 Conversion Course student)

QFI: A2 Cat QFI – 2483.2 hrs total time/961.1 hrs F-111; current

## Accident summary

The crew had just completed the first of two level auto direct weapon delivery passes on a 320° attack heading at 1000 ft AMSL and were conducting a climbing left-hand turn to the downwind leg. The last radio transmission the crew made was the intention to conduct the second attack on a 320° heading. Subsequently, the crew of a second F-111C, having just completed a bombing pass, noticed a large column of smoke south of the bombing range. Crew members attempted to contact the incident crew by radio without result.

Accident reconstruction indicated that shortly after straightening for the downwind leg, the aircraft's transparencies were shattered by a collision with at least one and probably three large birds.<sup>9</sup> The pilot under instruction was most likely totally incapacitated by injuries inflicted by both bird/s and windshield debris.<sup>10</sup> The instructor pilot may have been similarly incapacitated, but probably to a lesser degree. However, the instructor pilot would have been effectively blinded at this stage by high energy glass fragments, bird tissue and shredded fibreglass. Between 10 and 12 seconds after the birdstrike, ejection was initiated, almost certainly by the instructor pilot.

Ejection occurred at 520 kts, 720 ft AMSL, nose down and right wing down. Ejection parameters were well beyond the capabilities of the crew module, which impacted the ground approximately three seconds later,

nose down and with approximately 55° right bank. The module disintegrated on impact.

## Board findings

The Board made the following findings:

1. The primary cause of the accident was loss of control due to an extremely hostile cockpit environment resulting from a major birdstrike. There were no known contributory causes.
2. The 10- to 12-second period that elapsed between the birdstrike and ejection was probably the near minimum achievable when consideration is given to the likely factors of:
  - a. total surprise,<sup>11</sup>
  - b. severity of the birdstrike,
  - c. probable physical injuries,
  - d. the physical blindness and disorientation of both crew members,
  - e. the inability of the crew members to communicate, and
  - f. wind blast.
3. The type of birds that impacted the aircraft could not be determined.

*(Author's note: The limited bird remains found precluded type identification but they were suspected to be pelicans as they are common to the area, and are the only large birds in the locality that are known to fly that high and in a group.)*

## Recommendations

Board recommendations included that more emphasis should be given during F-111C

8. Category U is used for aircrew that are uncurrent and/or under training.

9. Points of impact were determined to be the left and right windscreens and left canopy.

10. The left-seat occupant was likely unconscious following the initial birdstrike, having been hit on the right side of the forehead with such force that the visor cover and both visors were broken, at the same time his head was forced back with such violence that his helmet left a 3/4 inch depression in the metal seat back structure.

11. The crew would have been completing post weapon-release checks and setting up for the next bombing pass, therefore it is unlikely that either crewmember was looking outside of the cockpit and saw the bird(s).

12. The Board noted that F-111C crew briefing procedures were centred on the assumption that the aircraft would be in autopilot mode at the time of a strike.

13. If the birds were in fact pelican-sized, canopy penetration may still have occurred, even if BIRT were fitted.



crew briefing on post-birdstrike procedures, to the drastic consequences of birdstrike while the aircraft is being flown manually.<sup>12</sup> Strong consideration should be given to ejection as an immediate action, particularly if the bird impacts the left windshield.

## Changes attributable to this accident

Changes to F-111 procedures and aircraft modifications that were more than likely influenced by this accident are:

1. Fitment of the Bird Impact Resistant Transparencies (BIRT).<sup>13</sup>
2. 82WG Standing Instructions provide advice that ejection should be considered if any doubt exists as to the controllability of the aircraft, particularly when at low altitude, following a birdstrike that penetrates the F-111 windscreen(s).

**Right: Birdstrike damage to pilot's side canopy – aircraft A8-133.**

**Below: Crew module crater – aircraft A8-133.**



# Inflight fire and ejection near Auckland, 25 October 1978, (F-111C A8-141)

**D**uring an emergency diversion following a wheel-well hot indication, the aircraft suffered a wheel-well fire. An ejection was initiated and the aircraft crashed into the sea near Auckland, New Zealand. The ejection was successful; however, both crew members suffered back injuries.

The incident crew were Number 2 of a day four-ship F-111 maritime strike mission operating from RNZAF Ohakea airbase, taking part in an Australian/New Zealand Exercise.

## Crew

Pilot: Cat C – 3232.8 hrs total time/283 hrs F-111; current

Navigator: Cat B – 2842 total time/1037.2 hrs F-111; current

## Accident summary

The wheel-well hot caution lamp (WWHL) illuminated during recovery from an autotoss weapon delivery profile. The incident pilot deselected afterburner, reducing the power setting of both engines to idle, and then completed the extant boldface emergency actions of extending the speedbrake (to ventilate the wheel-well) and selecting the air source selector knob (ASSK) to off (to close the 16th stage engine bleed air check and shut-off valves).

The landing gear was extended at 300 kts (to minimise heat/fire damage to the main landing gear). During the diversion to the recovery airfield, the WWHL went out (it was on for a total of 1 minute 23 seconds,

which is unusual as it historically goes out with ASSK selection of OFF or EMER) followed shortly by illumination of the forward equipment hot caution lamp (FEHL) and then the low equipment pressure caution lamp (LEPL).

During crew actions to alleviate the FEHL, the pilot inadvertently selected RAM (he intended to select EMER where the bleed air shut-off valves remain closed but ram air cooling is provided for cooling and ventilation) on the ASSK. The crew of one of the other F-111s who had rejoined to assist, advised that white smoke was coming from the aircraft. The incident pilot then selected EMER on the ASSK at which time the white smoke stopped immediately. Shortly thereafter the LEPL went out, followed by the FEHL.

Less than two minutes after repositioning the ASSK to EMER, the WWHL again illuminated. Inspection by the other aircraft revealed no abnormalities.

The incident crew then decided to dump fuel to reduce aircraft landing weight. During the fuel dump, the other aircraft reported an apparent reversal of flow of the dump plume, and an intense fire started immediately in the wheel-well. Fuel dumping was ceased but the wheel-well fire continued.

The situation compounded further with the right-hand engine instruments fluctuating wildly, illumination of the left and right fuel pressure caution lamps and right engine oil hot caution lamp. A loud thump from the rear of the aircraft was heard by

both crew members so the pilot initiated ejection (less than 14 minutes from initial WWHL illumination). The ejection was successful and the aircraft crashed into the water.<sup>14</sup>

## Board findings

The Board made the following findings:

1. The primary cause of the accident could not be determined. However, it was noted that much of the evidence pointed to a 16th stage bleed air duct failure in the wheel-well.<sup>15</sup>
2. It could not be determined whether the wheel-well fire was caused by the fuel dumping. It was noted that the pilot's decision to dump fuel was based on well-founded and widely accepted principles of airmanship at the time.
3. It could not be determined whether the bleed air check and shut-off valves were closed or open prior to ejection. (During wreckage inspection, the ball valve was found to be unseated; however, removal of electrical power following ejection should have opened the valve.)
4. The F-111 checklist procedures for illumination of the WWHL caution lamp were found to be deficient, as it caused the pilot to delay selection of the ASSK to a position where the bleed air check and shut-off valves could be closed. Additionally, the checklist did not contain a caution to advise the crew that repositioning the ASSK after initial selection might cause a shut-off valve to fail to the open position.

14. Approximately 80 per cent of the wreckage was recovered from a depth of 130 ft. A RNZN diver died during the salvage operation.

15. Wreckage examination showed that the main landing gear was severely damaged and would have certainly collapsed had the crew attempted to land the aircraft.

16. The emergency actions had recently been revised to conform to USAF procedures – the rationale to immediately ventilate the wheel-well area by opening the speedbrake – and to retain consistency with oil hot emergency procedures (speedbrake – extend, followed by ASSK – OFF or EMER as applicable). As a result of these new procedures, the incident pilot had to delay speedbrake extension for approximately eight seconds until airspeed was below the imposed speedbrake limit of 600 KIAS / Mach 2.0. This in turn delayed selection of the ASSK to OFF. The Board determined that the first priority should be to eliminate the most likely source of the problem and thereby stabilise the emergency, and then complete actions to ventilate the wheel-well.

5. The F-111C flight manual was found to be deficient in a number of areas compared to equivalent USAF publications (for example, post-ejection procedures).
6. The ASSK was assessed to be of poor ergonomic design as the OFF and EMER positions should have been together rather than at opposite ends of the available selections as, when passing through the other selections (L ENG, BOTH, R ENG), a signal is sent to open the shut-off valves.
7. An inspection program for 16th stage bleed air clamps should have been initiated prior to the accident as there was considerable evidence that the integrity of critical items of the environmental cooling system (ECS) were not satisfactory, as indicated from a three-and-a-half-year history of wheel-well hot incidents together with associated defect and failure reports.

## Recommendations

Board recommendations included:

1. F-111 checklist (and flight manual) emergency actions for WWHL caution lamp illumination be changed back to earlier procedures (ASSK - OFF or EMER, then extend the speedbrake)<sup>16</sup> and that a

caution be added to advise that the ASSK should not be repositioned after initial selection as the shut-off valves may fail to an open position.

2. The F-111 air conditioning control (ACC) panel should be fitted with a larger ASSK knob to aid crew tactile identification of the knob.

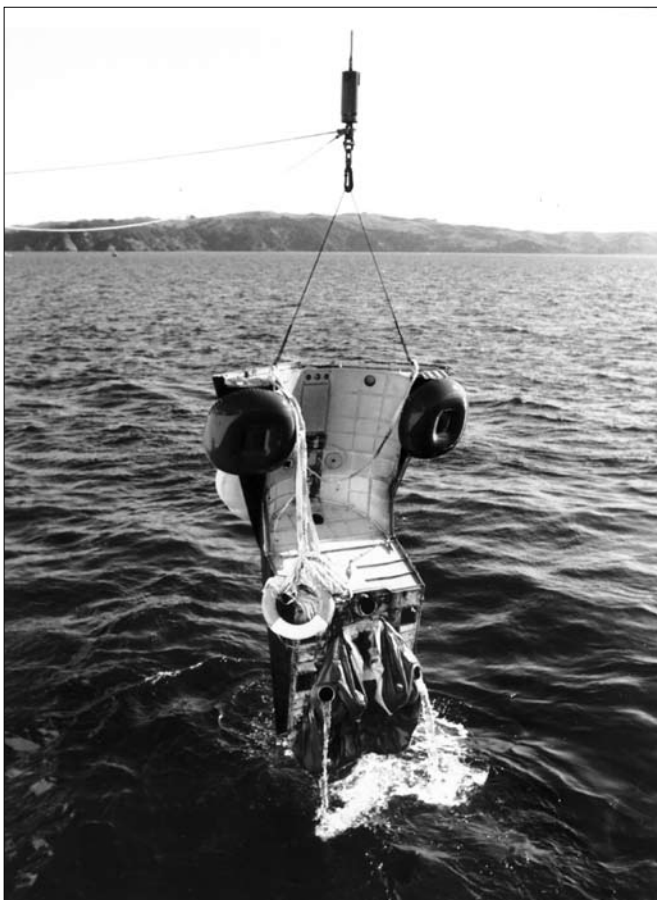
## Changes attributable to this accident

Changes to F-111 procedures and aircraft modifications that were more than likely influenced by this accident are:

1. Fuel dumping is not conducted following potential or actual overheating conditions such as indications of engine bleed air duct failure, engine oil hot, wheel-well hot, engine fire or fuselage fire.
2. Incorporation of a separate control switch on the ACC panel for manual RAM air door operation to provide the option for RAM air cooling following an emergency selection of the ASSK to OFF.

*(Author's note: The EMER position on the ASSK was subsequently removed as a selection option.)*

3. The wheel-well hot, engine oil hot and bleed duct failure orange caution lamps were changed to red warning lamps to assist the crew in quickly identifying the severity of the emergency indication.



Left: Crew module extraction - aircraft A8-141.



Below: Crew module - aircraft A8-141.

# Aborted takeoff and ejection

## Ohakea Airbase, 24 August 1979, (F-111C A8-137)

**D**uring an aborted take-off above refusal speed<sup>17</sup> following a double engine surge and afterburner blowout (caused by ingestion of surface water excited by the aircraft's nosewheels) the aircraft was unable to be stopped within the remaining runway.

The navigator initiated ejection at 90 kts and approximately 150 ft from the end of the runway. The aircraft continued down the slope beyond the runway (a drop of 100 ft only 30 ft from the end of the runway) where it impacted a roadway embankment and caught fire. The ejection was successful; however, the pilot suffered considerable back injuries.

The incident crew were Number 3 of a day four-ship F-111 maritime strike mission operating from RNZAF Ohakea airbase, taking part in an Australian/New Zealand Exercise.

### Crew

Pilot: Cat D - 1602 hrs total time/139 hrs F-111; current<sup>18</sup>

Navigator: Cat A - 4172 total time/1401 hrs F-111; current

### Accident summary

The profile of the 7000 ft long WWII vintage runway (RWY 27) at Ohakea that the formation used is atypical, as the centreline

is not the highest point. Both sides of the runway slope towards the centre of the southern side of the runway where a slot drain<sup>19</sup> is installed along its length. The runway's irregular longitudinal profile can also cause significant rainwater pooling, particularly along the centre of the southern half of the runway.

Around the time of the accident, the runways were often rigged with Type 34-B RAG (Runway Arrestor Gear) hookcables for RNZAF A-4 Skyhawk operations; however, the F-111 squadron commanding officer had directed that crews were not to consider the cable on take-off, owing to its incompatibility with F-111C aircraft at normal take-off weights. Weather at the time of the incident was prevailing rain, with a temperature of 11° C.

The incident pilot lined up the aircraft on the left side of the runway and behind the formation lead for the stream take-off. Neither crew member noticed the pooled rainwater on the runway and were unaware of the existence of the slot drain; however, the incident pilot did note the considerable spray that the lead aircraft generated during take-off.

Following brakes release, the incident pilot kept the aircraft on the left side of the runway (the pilot stated he was unfamiliar with the procedure of closing to the

centreline during a stream take-off) which resulted in the aircraft tracking through pools of water that were up to 25 mm deep.

Aircraft performance was normal through the briefed 105 kt refusal speed (which was based on a wet runway and no cable) and 120 kt acceleration time check.<sup>20</sup> Passing 130 kts, (2100 ft after brakes release and with only 4700 ft of runway remaining), the crew heard a bang, the navigator observed the engine nozzle indications closing (indicating a loss of afterburner), and both crew members sensed a marked loss of thrust. (Some of the witnesses, of which there were more than 100, observed spray, a fireball and smoke around the rear of the aircraft.)

The navigator communicated the loss of afterburners to the pilot [neither crewmember checked the exhaust pressure ratio (EPR) gauge that would have indicated whether the engines were still producing thrust] at which time the pilot unsuccessfully attempted to relight the afterburners by cycling the throttles back to military power and then into afterburner.

About 3800-4000 ft to go, the pilot decided to abort because he felt there was insufficient thrust and runway to continue.

The attempted abort, 25 kts above refusal speed and in hydroplaning conditions

17. F-111 refusal speed is the maximum speed that can be attained by accelerating with both engines at maximum afterburner and still stop on the remaining runway should the take-off be aborted. Decision speed – the speed at which the pilot commits to the take-off – is rotation speed or refusal speed, whichever is lower.

18. While the pilot had sufficient currency – he had flown 34 hrs in the past 30 days – his experience was limited. He had only graduated from F-111 Conversion Course approximately two-and-a-half months earlier where aircraft and simulator unserviceabilities had severely affected the course's progress with regard to continuity of training, achievement of day/night automatic terrain following flight and maritime strike qualifications, and had reduced flying training hours and hence F-111C experience.

19. The original WWII runway was widened (and lengthened) to accommodate larger aircraft, however the slot-drain that was on the southern edge of the runway was not repositioned and as a result is now located in the middle of the southern side of the runway.

20. While immaterial to the outcome given the engine problems occurred above refusal speed, the crew should have used an acceleration time check below the briefed refusal speed. For F-111 takeoffs (TF30-P-103 engines fitted), the acceleration time check was used to validate thrust. If the check failed (speed not within 10 kts) then the take-off was to be aborted. The 120 kt check speed was therefore of no value given the 105 kt refusal speed – the F-111 Performance Manual stated that the check speed should be chosen to be less than continuation and refusal speeds to allow a valid decision. (Author's note: F-111 crews no longer use acceleration time checks and simply prove engine thrust prior to brakes release using EPR gauge indications, as the F-111C is now fitted with the more powerful TF30-P-109 engines and F-111G aircraft are fitted with TF30-P-108 engines.)



Left: Take-off conditions at Ohakea airbase on 24 August 1979  
– aircraft A8-137.

Below: Abort above refusal speed – aircraft A8-137.



(without a suitable cable<sup>21</sup>), was futile.<sup>22</sup> Reliant on the departure end Type 34-B RAG to assist the abort, on passing 1100 ft to go, the crew realised that the hookcable was not rigged [it had been removed prior to the F-111s' take-off so that the RNZAF A-4s did not have to land beyond a rigged hookcable during their ground controlled approaches (GCAs) to RWY 09]. With 800 ft of runway remaining, the navigator realised that ejection was the only chance of survival and informed the pilot.

With the pilot still attempting to stop the aircraft, the navigator initiated ejection about 150 ft from the end of the runway. The crew module separated as the nosewheel left the pavement at the end of RWY 27.

The aircraft continued down the 100 ft drop-off, impacted a roadway embankment and caught fire before sliding to a halt, some 100 ft below and 500 ft from the departure end of RWY 27. The ejection module landed approximately 145 ft from the burning wreckage. Fearing the fire may spread towards the module, the navigator extracted and carried the injured pilot from the module.

## Board findings

The Board made the following findings:

1. The primary cause of the accident was selection of the least prudent take-off track.
2. Contributing factors included:
  - a. The lack of chined<sup>23</sup> nosewheel tyres caused surface water excited by the passage of the nosewheels to be ingested by the engines causing the

engine surge and afterburner blowout. (The modification to fit chined tyres had been suspended owing to problems experienced by the USAF).<sup>24</sup>

- b. Failure of the crew to diagnose complete engine condition following the afterburner blowouts (no check of EPR gauge readout).
  - c. Delaying ejection decision by deciding to abort some 25 kts above briefed refusal speed.
  - d. Lack of a compatible aircraft arresting system.
  - e. Pilot's failure to adopt the ejection posture prior to ejection.
3. The F-111C Flight Manual (and checklist) was deficient, as it did not address the matter of double engine failures during take-off.
  4. The 82 Wing F-111C Standard Operating Procedures (SOPs) were deficient as tracking of individual aircraft during the take-off roll for formation take-offs was not addressed.

## Board recommendations

Board recommendations included:

1. F-111 Flight Manual (and checklist) be amended to incorporate emergency procedures for double engine failures during take-off (abort if below refusal speed; eject if above refusal speed).
2. Consideration be given to the method and frequency of testing boldface emergency procedures.
3. The F-111C mission simulator be used more often to practice boldface emergency actions and immediate ejections.

4. Rebriefing crews on crew co-ordination concerning comparison of groundspeed versus distance to go during landings and aborted take-offs.
5. Rebriefing crews on the correct techniques for identifying and analysing engine malfunctions.
6. If pilots without a fighter background are selected for manning the F-111 force, then these pilots complete a full fighter introductory course (FIC) at 2 Operational Conversion Unit (2OCU).<sup>25</sup>
7. Priority be given to the purchase and fitment of a suitable chined nosewheel tyre for all RAAF F-111C aircraft.

## Air Command comments

The Air Commander (ACAUST) disagreed with the BOI and concluded that the primary cause of the accident was a double engine failure on take-off, at a position from which a successful abort could not be accomplished. He stated that the major reason why this situation arose was because the RAAF had accepted F-111 operations on runways without hook cables, which as demonstrated by this accident, extended to operating from short runways in very wet conditions.

ACAUST recommendations included:

1. RAAF F-111 aircraft not be operated in circumstances where a successful aborted take-off cannot be accomplished.
2. RAAF F-111 aircraft not be operated from wet runways unless hook-cables are available.

21. A warning in the F-111 Performance Manual at the time stated that if hydroplaning conditions exist, runway condition reading corrections (RCR corrections help provide an indication of aircraft braking effectiveness) are no longer valid and the crew should be prepared for a departure end barrier engagement. The F-111 dynamic hydroplaning speed is 115 kts (i.e. 9/165 psi).

22. The pilot also did not initiate maximum effort braking techniques immediately, despite being below maximum braking speed. Moderate braking was initially used followed by maximum braking.

23. Chined tyres have a protruding lip around the sidewall of the tyre to deflect the displaced surface water sideward rather than its normal upwards travel towards the engine intakes.

24. Corporate knowledge learnt from previous USAF trials regarding the dangers of water ingestion on F-111 engine performance was not retained at the RAAF operator level at the time of the accident. However, the F-111 Flight Manual did contain a warning stating that engine stalls may be caused by water ingestion if take-off is attempted with excessive water or slush on the runway.

25. Such a requirement was not previously considered as F-111 manning had historically come from Mirage or Canberra backgrounds. The incident pilot (as was another pilot on his F-111 Conversion Course – lead for the incident mission) was posted to Caribous from pilot's course before later being posted to F-111s.



## Changes attributable to this accident

Changes to F-111 procedures and aircraft modifications that were more than likely influenced by this accident are:

1. The introduction of chined nosewheels.
2. Requirement for aircrew selected for F-111 conversion that are of non-fighter background to first complete Introductory Fighter Course training.
3. Incorporation of emergency procedures for double engine failure on take-off.
4. The introduction of a Student Air Training Guide (SATG) requirement to close on the centreline by rotation.
5. The development of 82WG Standing Instructions wet runway limitations which:
  - a. prohibits operations where total dynamic hydroplaning is possible;
  - b. prohibits departures from runways where pooled water is visible (and cannot be avoided) if a departure end cable is not available; and
  - c. assuming that total dynamic hydroplaning and pooled water does not exist, allows a take-off without a cable only if  $V_{CONT}$  is less than  $V_{REF}$

**Right: Overhead of crash site (circled) and runway drop-off (the white line to the right of the runway number marking is the slot-drain) – aircraft A8-137.**

**Below: Crew module proximity to crash site – aircraft A8-137.**





# Sea impact off the coast of Moruya, 28 January 1986, (F-111C A8-139)

**D**uring a night simulated maritime strike attack, the aircraft crashed into the ocean approximately 52 nm east of Moruya, NSW. Both crew members were killed.

The incident crew were leading a fleet support maritime strike mission involving four F-111 aircraft. Approximately 1800 lbs of wreckage (about 3 per cent of the aircraft's total weight) was recovered from the ocean surface,<sup>26</sup> with indications that an ejection was not attempted and that both crew members died on impact. Weather at the time was 6 octas cloud cover with a base of 2500 ft and tops of 5500 ft. Conditions were very dark, with the moonrise (full moon) due to occur approximately 20 minutes after the accident.

## Crew

Pilot: Cat C – 861.1 hrs total time/523 hrs F-111; night uncurrent

Navigator: Cat C – 1372 total time/1177 hrs F-111; limited night currency (USAF Exchange Officer)

*Note: Neither crew (nor any of the formation members) had flown a dedicated maritime strike mission in the past 90 days due to a previous squadron focus on working up for, and competing in, a US Red Flag Exercise; the extended reduced activity period and the squadron grounding.<sup>27</sup>*

*The pilot had only flown 4.3 hrs night in the past 90 days, with no night hours in the last 30 days. The navigator similarly lacked sufficient night currency, with only 2.3 hrs night in the*

*past 90 days, of which 2.0 hrs night had been accomplished in the past seven days.*

## Accident summary

The mission involved simulated AGM-84 Harpoon anti-ship missile attacks by F-111 aircraft against three RAN ships operating in the Jervis Bay naval exercise area. Three of the F-111 aircraft were to conduct the attacks, with the fourth aircraft providing strike direction (i.e. targeting information). The incident crew were lead for the mission; however, the sortie was effectively conducted as single-ship operations as take-off times for the attacking aircraft were separated by 30 minutes. The pilot, although relatively junior, was the squadron Maritime Strike Officer responsible for specialising in and developing maritime tactics for squadron use.<sup>28</sup> The majority of the mission planning was left up to the lead crew, with assistance from the navigator of the third strike crew. Other formation members had limited input, mainly due to competing secondary duties.

The briefed tactics for the maritime strike included a climb from low level up to 8000 ft AMSL to acquire the target, simulate weapon launch and then fly the weapon's flight profile to provide the Navy maximum training value.<sup>29</sup>

For the post-release descent, the pilot wanted to try a new 'non-standard' tactic of simulating the rapid free-fall descent of the missile (to the flight authorised altitude limit of 300 ft AMSL) and then accelerating at low

level in accordance with known missile performance.<sup>30</sup> The only aspect of the descent profile briefed was the intention to use idle power with the speedbrake extended; however, the use of the speedbrake was later rescinded following advice from the flight authorising officer that it would be impossible to achieve the missile's known speed during descent if the aircraft's speedbrake was extended.

Target overflight was to be at 300 ft AMSL for aircraft conducting their first attack. The second (and last) attack for each aircraft would be conducted simultaneously with the following F-111 (on their first attack) therefore, at 12 nm to run to the target, the aircraft on second attack was to climb to 800 ft AMSL to provide 500 ft vertical separation between aircraft.

The incident crew completed the first attack to target overflight. During the subsequent second and co-ordinated attack, the incident crew transmitted the usual 'Bruiser' radio call indicating to the targeted ship that simulated Harpoon weapon release had been executed. A short time later the pilot of the fourth F-111 aircraft (i.e. the strike direction aircraft) noticed three fireballs on the ocean surface.

Concerned for the safety of other F-111 crews, the pilot of this aircraft initiated a formation radio check. No response was received from the lead crew. A mayday was declared and a search and rescue effort was then co-ordinated with the Navy.

26. The ocean depth at the accident site, being in excess of 1100 fathoms, precluded attempts to recover wreckage from the ocean floor.

27. The officer commanding had directed the squadron to cease the flying it had been conducting in early January as it was still the official base stand-down period.

28. The incident pilot was considered one of the more experienced non-executive squadron pilots compared to the relatively large number of inexperienced crews in the squadron. Witness statements indicated the incident pilot undertook the role of Maritime Strike Officer with enthusiasm.

29. For at least the past 18 months prior to the accident, the Navy had requested F-111 crews fly the Harpoon missile flightpath for the benefit of their ships' radar fire-control systems.

30. The squadron's maritime tactics were in a continual state of change, with new tactics often being employed (Harpoon was still relatively new to the F-111 community). The incident pilot was known to have been developing the immediate post-launch phase of the Harpoon missile profile. Squadron maritime tactics documentation was minimal due to their developmental and classified nature. The official F-111 tactics document was outdated having been written a number of years ago without any subsequent updates. However, the usual descent profile post simulated weapons release, was a shallow controlled descent with power set as needed to maintain required speed.

*Note: The second aircraft was unable to achieve the briefed descent parameters for simulating the Harpoon post-release flightpath and had to increase engine power setting to maintain the required speed.*

*Post-accident flight profile reconstruction indicated that a very high rate of descent (20,000 ft per minute) and nose-down attitude (20°) would be required if the missile's known speed of descent was to be achieved with an idle F-111 engine power setting. The Squadron CO, on hearing post-accident the briefed profile, had misgivings about the rashness of such a plan.*

## Board findings

The Board made the following findings:

1. The primary cause of the accident could not be determined. For undetermined reasons the aircraft impacted the water.
2. The most probable cause of the accident was that the aircraft impacted the water at either the bottom of descent or shortly

thereafter, when the crew were distracted by an internal or external occurrence that was of sufficient importance for the crew to fail to notice and initiate timely response to their immediate situation.<sup>31</sup>

3. Analysis of the limited wreckage recovered, indicated that the crew may have been taking recovery action to avoid contacting the water at time of impact.

## Board recommendations

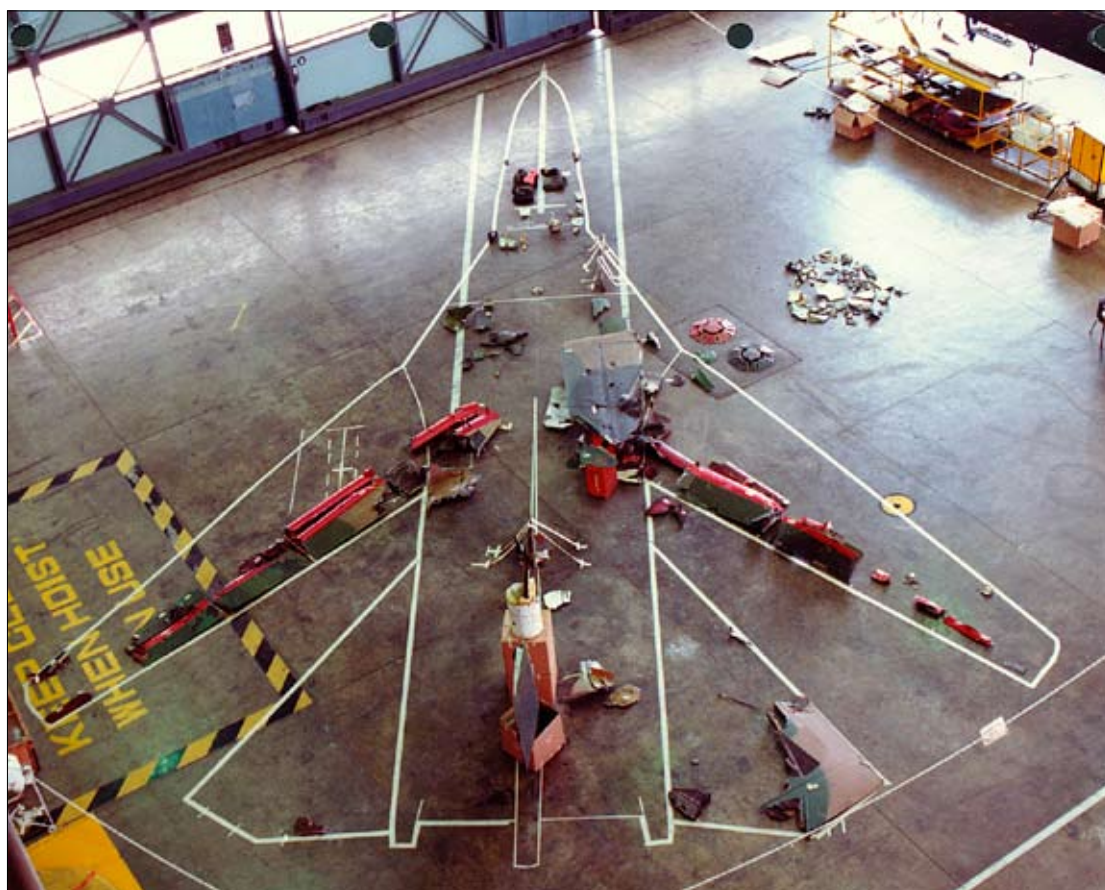
Board recommendations included the provision of an auditory warning for the F-111 radar altimeter (RADALT) be investigated.

## Changes attributable to this accident

Changes to F-111 procedures and aircraft modifications that were more than likely influenced by this accident are:

1. Introduction of rate of descent limits for night/IMC manual descents over land and water (maximum of 3000 ft per minute for descents below 5000 ft) and the requirement for the aircraft to be in a wings-level attitude for descents below 1000 ft ASL.
2. Eventual fitment of an auditory warning tone on illumination of the RADALT low light to provide additional cues to the aircrew that the aircraft had descended below the minimum altitude set by the crew on the RADALT bug.
3. Standardisation that crews are to set the RADALT bug to 90 per cent of the intended flight altitude for flight below 5000 ft AGL.<sup>32</sup>
4. Eventual rewrite (and update) of the F-111 Tactical Procedures (TACPROCs) Manual including maritime strike tactics.
5. Defined F-111 maximum crew duty limits.<sup>33</sup>

**Right: Layout of total wreckage recovered – aircraft A8-139.**



31. The probable causes considered were related to the developmental nature of the planned manoeuvres and crew distraction during a critical phase of flight.

32. At the time of the accident, there was no squadron policy for setting the minimum altitude for the RADALT low bug.

33. The Air Standing Instructions at the time did not specify a maximum crew duty limit and allowed judgement on the part of executive and authorising officers. While the incident pilot was within the generally accepted 15 hr limit, he had commenced duty at 0800 hrs on the day of the incident (crews typically turned up at lunchtime if they were night flying) and had been on duty for 12.5 hrs at the time of the accident.

# Ground impact near Tenterfield, 02 April 1987, (F-111C A8-128)

**D**uring the recovery from a night climb auto<sup>34</sup> weapon delivery profile against a simulated landstrike target near Tenterfield, NSW, the aircraft was observed to over-bank and commence a descent of approximately 10 degrees.

The descent continued with decreasing bank angle until just prior to impact, when the aircraft commenced an Auto TF fly-up. The aircraft impacted the ground with considerable downwards velocity; with a 5° nose up attitude, slightly right wing low and 3.5 to 3.7G applied. Aircraft break-up was extensive, with wreckage spread up to 1300 metres downrange. Both crew members were killed.

The sortie was the final handling test (FHT) for the student navigator prior to completing F-111C Conversion Course. It was the first F-111 FHT conducted by the pilot since his F-111C Qualified Flying Instructor (QFI) conversion.

## Crew

Pilot: Cat C F-111C QFI – 1776 hrs total time/873 hrs F-111; current

Navigator: Cat U – 2441 hrs total time/47.9 hrs F-111; (F-111 Conversion Course student)

## Accident summary

The incident crew departed East Sale, Victoria, prior to nightfall to lead a two-ship

F-111 formation public relations photo shoot (conducted by a chase aircraft) before separating for an 8 nm radar trail night sortie back to Amberley. Prior to the brief, both QFIs had decided (and were authorised) to simulate 'dying' at Evans Head air weapons range to assess the student navigators' reaction to the situation.<sup>35</sup>

The aircraft took off as planned, completed the photo shoot, separated to 8 nm trail and had completed the first planned sortie attack (climb auto tactic) successfully before proceeding on to the second attack at Tenterfield. The weather was fine; however, the evening was dark with limited moonlight.

The incident aircraft ingressed the target at 200 ft SCP on Auto TF at speeds varying between 480 and 540 kts and utilising available terrain for terrain shielding (to minimise exposure to simulated enemy defences). Following indicated simulated weapons release, for an unknown reason, the aircraft continued on attack heading for about four seconds longer than normal before turning to egress heading.

The aircraft did not achieve wings level above manoeuvre safety height (4000 ft AMSL) and in the latter stages of the turn, the aircraft over-banked and commenced a 10° descent. At some stage, one of the crew (probably the pilot) set 400 ft SCP on the TFR panel and 325 ft on the radar altimeter.

Between 2.5 and three seconds before ground impact, the aircraft commenced an Auto TF fly-up. The aircraft impacted the ground at 2800 ft AMSL.

## Board findings

The Board made the following findings:

1. The primary cause of the accident could not be determined.
2. The most probable cause of the accident was that the crew lost situational awareness with respect to altitude during a critical flight manoeuvre. Possible contributory causes for their loss of situational awareness included:
  - misreading the altimeter;<sup>36</sup>
  - distraction of the crew from the primary task;
  - lack of any external visual cues;
  - G-induced loss of consciousness (G-LOC);
  - pilot psychological profile (considerable personal life stressors – potential for decreases in performance/vigilance due to subjective fatigue); and/or
  - visual impairment or partial incapacitation of the pilot (due to a pre-existing chronic heart condition revealed at autopsy).
3. The crew were not manually controlling the aircraft at the time of the impact and no ejection was attempted.

34. The climb auto profile was used for simulated low-drag weapon releases, with the tactic enabling the aircraft to remain outside the weapon fragmentation envelope. At 15 seconds prior to the computed bomb release, the pilot overrides the TFR and pulls to 10° nose up, follows the command steering bars (which react to the navigator's radar update on the target), and at one second after bomb release indications (illumination of the bomb release light) and when above manoeuvre safety height, a 3G turn through 50° (or to egress heading whichever occurs first) is initiated. The aircraft is then established wings level with a 5° nose down pitch attitude, and, after the TFR fail lights have extinguished and the navigator confirms forward terrain radar video, the pilot releases the autopilot release lever and the aircraft automatically descends to the selected TFR SCP.

35. The usual inflight diversion used by Training Flight instructors to further test the students on their FHT was not possible because of insufficient fuel remaining (following the planned photo shoot) for such a diversion.

36. During flight profile reconstruction sorties, one of the pilots twice misread the F-111 tape system altimeter during the post-weapon release manoeuvre, mistaking the actual altimeter reading of 4800 ft AMSL as 5800 ft AMSL. A natural reaction to this misread would be to over-bank and establish a nose-low attitude to minimise exposure to possible (simulated) enemy defences. Once the bank angle was reduced through 45°, the TFR fail lights would extinguish as planned, and the navigator's attack radar video would return. The pilot would therefore assume that the TFR would automatically descend the aircraft back to low level (once the autopilot release lever was released) but with the aircraft too close to the ground (due to the misreading of altitude) the aircraft would commence an automatic TFR fly-up (at 68 per cent penetration of the selected TFR SCP). The standard procedure is for the pilot not to take over during a fly-up. Under these parameters, the time between fly-up initiation to ground impact would have been less than three seconds, providing the pilot little time to perceive, analyse and react to the situation.

The following factors also emerged during the investigation:

**Standardisation.** A lack of standardisation between crews was evident in several areas:

- a. The acceptable nose-down attitude for the post-attack escape manoeuvre for the climb auto tactic was briefed as 5°, but was not stressed as a maximum (some crews actually used 10° nose down). *(Author's note: This is a flawed procedure anyway, as a check for correct climb/dive response of the TFR system at the beginning of the descent cannot be accomplished as the aircraft is already in a dive when Auto TF flight is recommenced.)*
- b. Variation of pilot scan priorities during TF letdown (some concentrated almost wholly on the ADI, to the exclusion of the TFR E-scope or altimeters – significant ground echo penetration of the Zero Clearance Line on the E-scope would have been displayed during the incident aircraft's post egress descent).

**Lack of official sanction for climb auto tactic.** The Board was unable to find any

official sanction for the climb auto tactic and, following interviews with a large number of F-111 crews, it was evident that there was a variety in techniques in flying the tactic.

It was also apparent that there was a poor appreciation of both TFR system capability and crew monitoring procedures during TF descents. Of particular concern was the adopted procedure of descending straight back to a low SCP setting, even though the flight manual and conversion course student notes advised using an initial 1000 ft SCP.

Such a practice also reduced the possibility of the TF system's automatic 68 per cent TF fail protection being able to save the aircraft in many circumstances.

**Climb auto tactic out of context and unnecessarily hazardous.** The tactic was recognised as being not operationally significant, yet its execution was much more demanding than the tactics used by the operational F-111 squadron (ISQN tactics were focused on laser guided bomb employment using the F-111C Pave Tack targeting system). It was noted that 90 per cent of the weapon

delivery tactics flown on the F-111 Conversion Course were climb autos.

**Lack of liaison between F-111 squadrons.** The lack of liaison between the squadrons precluded 6SQN Training Flight from updating the training procedures to optimise student experience for the operational techniques at 1SQN. Similarly, the lack of feedback on graduate performance at 1SQN left an open loop in the training cycle.

**High workload of training flight.** Training Flight workload was compounded by the shortage of QFIs, resulting in a high workload for the remaining instructors. (As an example, the workload precluded Training Flight from updating the course material in time for the next conversion course that would include new systems – Pave Tack.)

**Supervision.** Training Flight Commander (TFC) supervision was compromised with the need for the TFC to contribute significantly to course instructional flying due to a shortage of QFIs (high loss rate to airlines). As a result, some TFC directives were not being followed, namely:



Left: The final flight – photo shoot prior to departing for home – aircraft A8-128.

- a. requirement to 'bug' manoeuvre safety height on the altimeter command bar (the incident pilot had not – it was set to the leg safety height of 6000 ft AMSL); and
- b. noise considerations for the target area dictated a climb auto weapon delivery profile (one crew had planned a level attack).

**FHT complexity.** The incident pilot did not seem to share the TFC's view that the FHT was to be 'low key – an ordinary trip'. (The incident pilot had thought up the idea of testing the student navigator by 'dying' at the range and the delay in pull-up for the climb auto tactic may have been to compress the time available for the student to locate the target on radar.)

**Route surveys.** Authorisation to fly at 200 ft SCP seemed to be based on the AGL altitude that the radar prediction for the target had been drawn for (a 200 ft prediction implying a 200 ft route survey had been conducted). There was no record kept of when the routes were surveyed and who had conducted the survey.

The Board could not find any guidance or instructions in relation to the method of surveying, the recording of survey results or a requirement for a periodic re-survey. (At the time, maps up to 199 ft high were not printed on the types of maps that were used by the squadrons.)

**TFR letdowns.** For at least 3.5 years, F-111 crews had descended to ingress SCP after a simulated attack. The extant flight manual recommended an initial level-off altitude of 1000 ft, then step down. USAF F-111 procedures were in accordance with the flight manual. Regardless, evidence pointed to the incident pilot using a 200 ft SCP ingress and then re-selecting 400 ft SCP during the recovery.

While non-standard, and a possible distraction to task priority, the Board noted

that it indicated caution on the pilot's part with respect to TF descent straight down to 200 ft AGL in an aircraft with a history of flying low on SCP.

**Safety height calculation.** The two F-111 squadrons used different methodologies for calculating target area manoeuvring safety heights. Additionally, the students flying the incident mission had calculated safety heights individually, and results varied from 4000 to 4900 ft AMSL.

**Differences between TFR warnings and cautions in F-111C Flight Manual vice USAF F-111A Flight Manual.** The RAAF F-111C Flight Manual lacked some of the warnings and cautions relating to TFR operations that were contained in the USAF F-111 Flight Manual. One warning that was omitted described a potentially dangerous situation where video returns of approaching terrain could be insufficient for TF forward-looker computation yet preclude LARA (low altitude radar altimeter) over-ride operation. (Aircraft manufacturer representatives at the time stressed that the key to safe night or IMC low level TF is crew vigilance and cross checking of all available information.)

**Requirement to wear anti-G suits.** There was no policy or requirement for F-111 crews to wear anti-G suits (the incident crew were not wearing anti-G suits).

**Crew aide-memoirs.** The Board found it disturbing that the Conversion Course students were encouraged to develop their own aide-memoirs (handwritten versions of selected checklist sections). The Board noted that this practice had many possible adverse implications in checklist currency and in the worst case, flight safety.

## Board recommendations

Board recommendations included:

1. Review the F-111 operational role and training requirement to ensure tactics

development is supported within the squadrons by specialist training and adequate supervision.

2. Review current tactics and profiles to ensure that they are a realistic compromise between operational requirements and flight safety.
3. Ensure F-111 Conversion Course training is conducted in accordance with the approved syllabus. (*Author's note: The Board noted that 13 targets were flown at 200 ft SCP vice five on the approved syllabus, and therefore did not provide a building block approach to learning.*)
4. Establish procedures that ensure that F-111 conversion training is relevant to Strike Reconnaissance Group (SRG) requirements and that feedback on recent graduates is provided to 6SQN Training Flight.
5. Review capability of 6SQN Training Flight to adequately perform its present level of tasking in view of the declining experience levels.
6. Establish guidance and instructions for performance, recording and review of route surveys for 200 ft SCP TFR flight.
7. Assess the requirement for marking of obstructions on maps for F-111 operations.
8. Re-evaluate the decision not to adopt USAF series trim tie-in checks into F-111C TF Ground Operational Checks.<sup>37</sup>
9. Evaluate F-111C/USAF Flight Manual differences for F-111C Flight Manual amendment action.
10. Review the current policy on wearing of anti-G suits.<sup>38</sup>
11. Review the present practice of F-111 aircrew taking the Weapons Systems Performance Document (WSPD)<sup>39</sup> on land away exercises (the WSPD for the incident aircraft was destroyed in the accident).

37. These checks were adopted by the USAF in 1983 following two fatal accidents. (There was concern at the time of the RAAF investigation about series trim tie-in of the incident aircraft.)

38. The Board did not agree with the belief of one of the witnesses that anti-G suits should be worn for all F-111 sorties but would support a recommendation that anti-G suits should be worn for all sorties involving repetitive G or tactics.

39. The WSPD book is used by F-111 aircrew to document information of a nature relevant to aircrew interpretation of the performance of applicable aircraft systems (for example inertial navigation system accuracy/inaccuracy, weapon system delivery accuracy, TFR ride heights.) The intent of the document is for the next crew using the aircraft to be able to check the history of the aircraft's performance prior to flight.



## Air Command comments

The Air Commander at the time made these comments:

1. There was a need for the introduction of a stress management education program.  
*(Author's note: This comment regards the lack of supervisor awareness of the incident pilot's high stress levels.)*
2. Preservation of assets must take precedence over realism of operational training - the ADF cannot afford training programs that unduly risk aircraft and crews. Balance is needed between peacetime training limitations versus the wish to strive for realistic operational training (particularly given the current strategic outlook).  
*(Author's note: The general consensus among F-111 crews revealed during the Inquiry regarding descent straight to 200 ft SCP was that the "aircraft should be able to hack it" and "it is the way we would go to war.")*

## Changes attributable to this accident

Changes to F-111 procedures and aircraft modifications that were more than likely influenced by this accident are:

1. The climb auto tactic was eventually revoked (mainly due to lack of tactical applicability).
2. Auto TF descents are initiated from 5000 ft AGL minimum (i.e. above the 1700 ft AGL minimum to account for the flight manual warning stating that 1700 ft AGL is the minimum altitude at which the pullout should commence on an auto-TF letdown).
3. 1000 ft SCP is now selected as the initial SCP for all auto TF descents (in line with flight manual advice). Subsequent SCP stepdown is done so progressively, with a check for level-off response at each setting.
4. Route surveys are conducted in accordance with Defence Instructions for all new low-level routes outside surveyed areas. If flight is to be conducted on unsurveyed routes, then further restrictions are placed on authorised flight altitudes (including 400 ft SCP day VMC and not below 750 ft SCP night/IMC).
5. 200 ft SCP flight (day/night/IMC) can only be conducted within surveyed air weapons ranges. If 200 ft SCP flight is desired for additional surveyed routes, then specific authorisation from the Officer Commanding 82WG must be sought.
6. Anti-G suits must be worn by all F-111 crew members.
7. Abbreviated checklists (aide-memoirs) for select normal procedures are now included in the F-111 Flight Manual for crews to copy and use, thereby ensuring accuracy and currency.



Above: Ground impact scar – aircraft A8-128.

Below: Wreckage reconstruction – aircraft A8-128.



# Ground impact near Guyra, 13 September 1993, (F-111C A8-127)

**D**uring the recovery from a night autotoss<sup>40</sup> weapon delivery profile against a simulated landstrike target near Guyra, NSW, the aircraft impacted the ground and disintegrated. Both crew members were killed.

The sortie was the first of three F-111 aircraft, at 10 minute intervals, flying a night Auto TF strike mission. The accident occurred after 23 minutes of flight and at the first simulated target attack. The mission was designed to reinstate squadron proficiency in night operations as squadron aircrew had not conducted night operations for some time due to other squadron commitments. Weather in the target area noted by the second aircraft in 10 minutes trail, was 4 octas cloud cover at 400 ft AGL with 8 octas cloud cover entered soon after pull-up for the weapon delivery.

## Crew

Pilot: Cat C – 1427 hrs total time/225 hrs F-111; night uncurrent

Navigator: Cat C – 3809 hrs total time/291 hrs F-111; night uncurrent

*(Author's note: The pilot had flown only 4.5 hrs night in the past six months and had not flown an autotoss/night-autotoss for five months. The navigator had only flown 6.9 hrs total in the past 30 days. They had only flown once together on the F-111 – approximately six months prior).*

## Accident summary

The incident crew were assigned the task of briefing the mission as a wave brief for all three aircraft. The briefing, while satisfactory, was considered rushed, which

was uncharacteristic of the pilot. Completion of secondary duties (the pilot was the squadron Times Officer which has a high workload) may have reduced the pilot's flight preparation time as he was observed to be still completing the briefing slides 10 minutes before brief commencement.

Target ingress was conducted on Auto TFR. The pilot initiated pull-up to commence the weapon delivery profile (military power, 3G, 15° autotoss) and appeared to have difficulty achieving the required G (TF audio indicated aircraft dive commands). At 20-25° nose up, the Auto TF system commanded a fail safe fly-up with accompanying TF fail audio (probably due to system loss of 'data good').

The pilot then rolled the aircraft to the right in a climbing turn to complete the autotoss manoeuvre. Approaching the apex of the climb, the aircraft was overbanked and the Pave Tack system went into memory point track, thereby precluding tracking of the target by the navigator. The roll was then reversed to reduce bank angle, with the aircraft reaching a nose down pitch attitude greater than 25°.

As the pilot rolled out on egress heading, the aircraft impacted the ground. Impact parameters were approximately wings level, a 25° nose down pitch angle, 483 KTAS, 37° flight path angle below the horizon and a 30,000 ft per minute rate of descent. Throughout the manoeuvre, weapon release timing indications remained at time-to-go (TTG), with no transition to time-to-impact (TTI).

## Accident Investigation Team findings

The Accident Investigation Team (AIT) made the following findings:

1. The primary cause of the accident could not be determined.
2. The most probable cause of the accident was that the pilot, after omitting to disengage the Auto TF system on the pull-up<sup>41</sup> for the autotoss weapon delivery, through loss of situational awareness, placed the aircraft in a flight path vector from which impact with the ground was inevitable.
3. Factors that may have contributed to the accident were:
  - a. The pilot had not practised this particular kind of attack at night for the preceding five months.
  - b. The pilot's possible over-confidence which may have lulled him into having such faith in his own abilities that his preparedness for airborne problems was low. Consequently, when faced with a highly demanding situation, he was unable to cope with it.
  - c. The pilot may have been distracted when he possibly realised he had forgotten to disengage the Auto TF system on pull-up initiation during the attack, or by some other unknown factor such as an aircraft component or system failure.
  - d. The pilot may have suffered from channelised attention due to task saturation.

40. The autotoss manoeuvre is flown entirely by reference to flight instruments. It involves a run in to the target at 400 ft SCP and 540 kts in Auto TF. At the pre-determined pull-up point, the pilot depresses the bomb release button ('pickle'), overrides Auto TF (by depressing the 'paddle' autopilot release lever) and then commences a pull-up (3G for 15 degree climb angle manoeuvres, 4G for 25 degree climb angle manoeuvres). This sequence is commonly verbalised as 'pickle, paddle, pull'. The time-to-go (TTG) readout counts down to zero where bomb release automatically occurs, at which time the reference changes to time-to-impact (TTI) – i.e. time to bomb impact. Following weapon release and once above start roll altitude (SRA), the pilot then turns away from the target using 110° angle of bank. With the aircraft in a descending turn, bank angle is reduced to 70° when, either the target safe altitude (TSA) is reached, or the aircraft's pitch attitude reaches the horizon, as indicated on the attitude display indicator (ADI). The reduced bank angle is maintained until the required heading change is achieved, at which time the aircraft is rolled to wings level, 1000 ft SCP is set on the TFR panel, and, once cleared for descent (TF fail lights out and good radar video returns), the Auto TF is re-engaged and the aircraft automatically descends back to low level.



- e. Confusion over the unexpected behaviour of the aircraft may have caused him to focus on what was going wrong, to the detriment of situational awareness and the primary task of flying the aircraft.
4. 82 WG documentation, while detailing autotoss abort criteria, does not specify autotoss abort procedures. (Different F-111C pilots quoted different procedures.)
3. Mandated requirement to verbalise 'paddle, pull, pickle'<sup>42</sup> and keep the paddle switch depressed for the duration of the toss (including VMC toss profiles where TFR is not used).
4. Loss of situational awareness added to the list of toss abort criteria.
5. Techniques to be used for aborting the toss manoeuvre now specified in 82WG Standing Instructions.
6. 82WG Standing Instructions specify standard crew commentary to be used when conducting toss weapon deliveries including pilot actions required should the navigator advise that the Pavé Tack system has entered memory point track (possible indication of incorrect aircraft attitude, toss profile not executed correctly).

## AIT recommendations

AIT recommendations included:

1. Review the 82WG categorisation scheme and currency requirements to reflect currency requirements for night flying and night weapon-delivery profiles.
2. A standard 'patter' for the autotoss delivery should be used by all F-111C crews, this 'patter' should include:
  - a. the words 'pickle, paddle, pull' to indicate that the pilot has in fact paddled off, and
  - b. the words, 'three balls, rolling' to indicate that the pilot has in fact ensured that the three attitude indicators have been checked and that they correspond.
3. Pilots should depress the paddle switch for all autotoss deliveries (i.e. including manual flight deliveries).
4. Abort procedures for autotoss deliveries be documented in the 82WG F-111 SOPs.
5. Air Command should introduce a formal risk management process that addresses crew/task matching.

## Changes attributable to this accident

Changes to F-111 procedures and aircraft modifications that were more than likely influenced by this accident are:

1. Introduction of a more formal categorisation and currency system that provides increased visibility of currency issues to flying supervisors.
2. Increased use of the F-111C simulator for toss currency training.



Above: Impact crater near Guyra – aircraft A8-127.

Below: Wreckage recovery – aircraft A8-127.



41. During day attack profiles, the pilot had a habit of flying the aircraft manually rather than on Auto TF. In such circumstances, the pilot would simply authorise weapon release and pull-up at the required point. He would not have to disengage the TFR system as it would be turned off.

42. The sequence order was changed to 'paddle, pull, pickle' to provide applicability to both GBU-10/12 Paveway II and GBU-24 Paveway III weapon deliveries.

# Ground impact Aur Island, 18 April 1999, (F-111G A8-291)

**D**uring a night simulated maritime strike attack, the aircraft impacted trees on an 1100 ft ridge on Pulau Aur (Aur Island), 24 nm to the south east of Pulau Tioman (Tioman Island), and off Malaysia's east coast. The aircraft was destroyed during the impact and subsequent fire. Both crew members were killed.

The incident crew were leading a flight of two F-111G aircraft conducting an unopposed maritime strike against a naval task force during an Integrated Air Defence System (IADS) Exercise. Weather conditions in the vicinity of the accident included medium and high-level cloud layers with little moonlight resulting in an extremely dark night.<sup>43</sup>

## Crew

Pilot: Cat A – 2121 hrs total time/1016.4 hrs F-111; current (qualified test pilot)

Navigator: Cat C – 2682 hrs total time/926.5 hrs F-111; current

## Accident summary

The mission involved simulated AGM-84 Harpoon anti-ship missile strikes by the two F-111G aircraft against the naval task force that was positioned to the south east of Aur Island in the South China Sea. The incident crew were lead for the mission. Planning for the mission was completed in phases, mainly because the information required was received at intervals from the Exercise tasking authority.

Some of the basic mission planning had been completed before the deployment (master map<sup>44</sup> for mission planning showing airspace restrictions and other pertinent exercise information and basic mission data-point load). The incident navigator carried out the final specific planning (including the attack profile) with some assistance from the other navigator in the formation.

A late change in routing had been received by the tasking authority, effectively allowing free play in the exercise area. However, the new tracks were probably not drawn on the maps (the second navigator did not amend his map) and the original and potentially misleading information was not removed from the mission cards or maps – the change in waypoint routing significantly altered ingress heading and distance to run.<sup>45</sup>

Input by the incident pilot during mission planning was minimal as his focus that afternoon was on the development of an engine test schedule that 82WG had tasked him with. The second pilot had no input into the planning as his offers of assistance had been declined by the incident navigator because he had the matter suitably in hand.

The briefed tactic was to ingress at low level and splitting to fly either side of Tioman Island (inside the 10 nm restricted area) to use terrain shielding and minimise detection by the naval task force, before turning back onto attack heading and climbing to acquire

and designate the target. Post simulated missile launch, the aircraft would then fly the missile flightpath at low level for a simultaneous target overflight.

The only briefing relating to terrain concerned the larger (Tioman) island. There was no mention of the two smaller islands (which included Aur Island that the incident aircraft impacted) on ingress heading. However, the incident navigator did stress the importance of using the attack radar to clear ahead and not to overfly any radar returns.

There was also no mention of the use of the TFR system for ingress to the target post weapon release. (After the brief, the second crew decided to fly all low-level segments on TFR as a consequence of the pilot's lack of currency and the crew's concern with obstacles in the South China Sea operating area.) Flight authorisation was accomplished by the incident navigator.

Accident reconstruction indicates that the incident crew used TFR during the low-level overwater segment to Tioman Island. In the targeting phase the pilot disengaged the TFR system.

The navigator experienced some difficulty in targeting the naval task force and may have become task saturated during the targeting process – the F-111G is not Harpoon capable and requires the navigator to effect a time consuming work-around procedure to get the required aircraft system

43. SAR crews reported that it was very difficult to see the island that the aircraft had impacted.

44. The master map was not prepared specifically for the deployment and had been used in previous IADS exercises. The map did not include the recently issued restricted zone and requirement for exercise aircraft to remain outside a 10 nm radius of Tioman Island. The route planned by the incident navigator infringed this restricted area.

45. The crews used maps that had been prepared the previous Friday as the routing to the exercise area was standard and had been flown before. However, the map was not amended to include the route to the initial point or target ingress, with neither the ingress track, distance to run nor heading marked, and accordingly provided no cues to enhance situational awareness of aircraft track and proximity to the islands. This lack of map detail for target ingress was a widely accepted practice on the grounds that maritime strike missions involve moving targets and therefore the position of the targeted forces cannot be determined with any certainty, particularly in the planning stage. While this may be practical for blue water (open ocean) maritime operations, it is not necessarily suitable for operations in the littoral environment as such an omission would reduce crew situational awareness in relation to the proximity of land masses and obstructions in the operating area. The mission cards likewise did not provide adequate cues to assist situational awareness of track proximity to the islands. Further, the mission planning was flawed as a result since the simulated Harpoon missile would have likewise impacted Aur Island and not reached the intended target.

indications for simulated weapon release. Once the targeting was complete the pilot manually descended the aircraft to 1000 ft AMSL (TFR was not used).

The navigator was then preoccupied with compiling the information required for the 'Bruiser' radio call that informs the targeted naval force of F-111 weapon release, and did not observe the radar returns of the two smaller islands directly ahead of the aircraft. At five seconds before aircraft impact the radar altimeter's low altitude audible warning sounded and the radar altitude bars were visible in the attack radar – the latter warning is unique to the F-111G<sup>46</sup>.

Indications are that the pilot may have responded to an unexpected visual sighting and attempted to climb the aircraft; however, the aircraft impacted trees on a ridge on the island, killing the crew.

## Board findings

The Board made the following findings:

1. The primary causes of the accident, listed in approximate sequence rather than in any order of significance were:
  - a. Inadequate pre-flight preparation for the mission, in particular:
    - failure to realise the probable aircraft track relationship to the smaller islands in the planning stage,
    - the accident navigator's failure to adequately brief the threat posed by the smaller islands, and
    - the accident pilot's failure to adequately check the aircraft route proposed by the navigator and realise the significance of the topography of the smaller islands.
  - b. Failure of the pilot to use all the aircraft systems available to him to reduce the hazard posed by the smaller islands.

- c. Failure of the navigator to prioritise his cockpit workload so that he could identify and help avoid the primary terrain hazard.
- d. Low crew numbers and high operational tempo leading to the development of a culture where aircrew fail to check other individuals' preparation and contribution to mission planning.
2. Contributing factors pertinent to the accident included:
  - a. Work practices developed within the Eastern Australian Exercise Area that did not place a high priority on terrain influences during simulated maritime strike sorties.
  - b. Failure of the crew of the second aircraft to adequately convey the risks perceived in the mission and the measures subsequently discussed and implemented to mitigate against those risks.
  - c. Tasking of the incident pilot by higher authority (82 WG) without the member's commanding officer's knowledge, and without adequate consideration of the additional workload such tasking would place on an individual.
  - d. Failure of the detachment to adequately mark all pertinent airspace on their master maps.
  - e. Failure of the Exercise authority to provide timely and accountable distribution of Exercise Instructions and associated Aircrew Information Publications (AIPs).
  - f. Lack of an independent flight authorisation.
  - g. Failure of the RAAF to:
    - promulgate a risk management policy for aircraft operations, and
    - educate aircrew in the procedures and practices to be adopted in identifying,

analysing, addressing, monitoring and controlling risk.

## Board recommendations

Board recommendations included:

1. A review and implementation of policies for the use of aircraft systems (such as the radar altimeter) in the prevention of Controlled Flight into Terrain (CFIT) accidents.
2. The introduction of an enhanced Crew Resource Management (CRM) program within the RAAF that would address the problems of aircraft command and a number of other crew co-ordination and planning aspects identified during the Inquiry.
3. Ensure clearly defined objectives for forces deployed for exercises and operations to ensure sound tactical weapon application is maintained after a thorough risk assessment.
4. A thorough review of RAAF orders and policies and amendment thereof with regard to postings of executives and required refresher training.<sup>47</sup>
5. Introduction of formal risk assessment for RAAF (and ADF) air operations.
6. All F-111 crew carry a SAR commander's checklist.

## Changes attributable to this accident

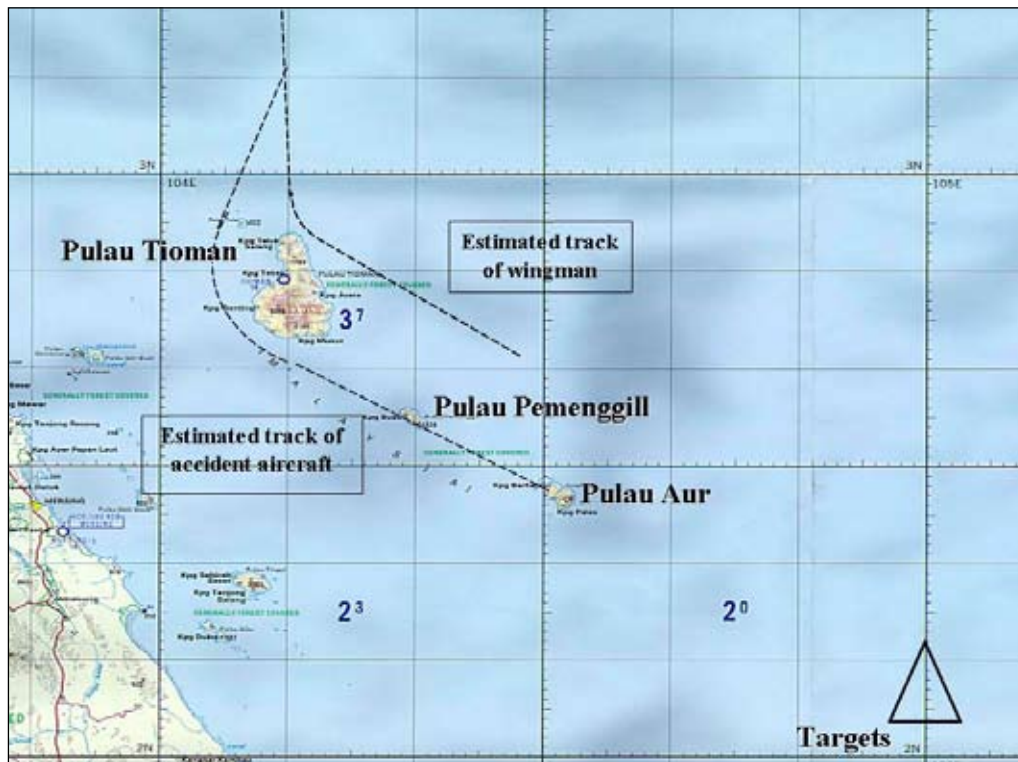
Changes to F-111 procedures and aircraft modifications that were more than likely influenced by this accident are:

1. Eventual introduction of a formal risk assessment process (Aviation Risk Management) for ADF air operations.
2. Implementation of an F-111 specific CRM course.

46. The RADALT is not specifically designed as a ground proximity warning system though it can be used as such to a limited degree (it only provides an indication of distance between the aircraft and terrain directly below it). Given the pilot had set the altitude bug to the intended cruise altitude of 1000 ft AMSL and the lack of guidance in relation to crew response to RADALT warnings, it is debatable whether the pilot would have interpreted the RADALT warning as an indication of rapid ground approach requiring an urgent response, or simply as an indication that the aircraft had drifted below the intended flight altitude requiring some minor correction.

47. 82WG Standing Instructions did not specify a requirement for refresher training and no formal syllabus had been established for such training. Refresher training requirements were simply tailored for the particular needs of the individual. The incident navigator did not receive any formal refresher training on being posted back to flying duties following a two-year staff tour.





Left: Estimated track to impact point – aircraft A8-291

Below: Final impact crater Aur Island – aircraft A8-291.





3. Removal of the tailored refresher; all aircrew refreshers now use a single, comprehensive curriculum.
4. Stipulation that where possible, self-authorisation of flight should be avoided. Further, if a self-authorising officer is part of a formation, then they are required to maintain independence by limiting planning activities to weather and NOTAMS, aircraft allocation and domestic duties such as copying.
5. Specification that F-111 maritime strike profiles are to be commensurate with the aircraft's capabilities and roles. Accordingly, F-111G aircraft are not to simulate anti-ship missile attacks.
6. F-111C aircraft may only simulate anti-ship missile overfly post release in day VMC.<sup>48</sup>
7. The requirement for night/IMC operations below safety height within 25 nm of known land, obstructions, or in archipelagic regions to be conducted on Auto TF.<sup>49</sup>
8. Procedures for operations below safety height outside 25 nm of known land or obstructions were also developed, including the specification that the navigator's primary duty becomes obstacle/terrain clearance by radar monitoring.
9. The requirement for a serviceable attack radar (which was to be used in conjunction with the TFRs for terrain avoidance for any flight below safety height) was mandated.
10. Guidance for the use of attack radar modes was developed. Specifically:
  - a. the time spent in GND VEL<sup>50</sup> and AIR-TO-AIR modes was limited to time/distance previously cleared in GND AUTO, and
  - b. use of 80 nm (F-111G) and 48 nm (F-111C) radar ranges for terrain avoidance was discouraged.
11. Addition of a SAR Commander's checklist in the 82WG Aircrew Information Folder (AIF).
12. 82WG Standing Instructions specify required crew actions in the event of RADALT warnings.

**Below: Sifting through the evidence – aircraft A8-291.**



48. This is the second F-111 accident occurring while simulating Harpoon missile flightpath.

49. Approximately one year after the accident another F-111 crew, while resetting for a night target attack, inadvertently found themselves within a quarter mile of the same island that A8-291 crashed into. The navigator did not see the island on radar because of task saturation and only realised where they were when he saw the lights of fishing vessels disappearing behind the dark land mass of the island. While the aircraft was not on a direct course with the island and the crew were flying with the TFRs engaged, it is disconcerting that all other defences had failed and that the TFR was effectively providing the last line of defence.

50. The GND VEL mode provides a ground velocity stabilised expansion of the area around the aimpoint cross-hairs and therefore does not provide the full radar picture ahead of the aircraft that GND AUTO provides.

# Ground impact Great Palm Island, 18 November 1987, (AF/A-18 A21-104)

**W**hile conducting a night solo radar navigation and bombing sortie, the aircraft impacted a hill on Great Palm Island off the coast of Townsville, Queensland. The pilot was killed instantly.

The incident pilot was a student on the Basic Hornet Conversion Course and had deployed with 20CU to Townsville as part of the air-to-surface phase of the course. At the time of the accident, the incident pilot was established in the bombing pattern, in company with the airborne Range Safety Officer<sup>51</sup> (and instructor), and was to conduct two low-level bombing passes before recovering back to Townsville.

Weather in the range area was four octas cloud base at 2500 ft with tops to 7000-8000 ft. The moon had not yet risen and consequently the range area was very dark with no significant man-made illumination.

## Crew

Pilot: Cat U - 1007.5 hrs total time / 74.4 hrs AF/A-18; (Conversion Course student)

*Note: The accident sortie was the pilot's first night solo sortie and night radar navigation sortie in the AF/A-18 Hornet – the planned night solo sortie at Saltash Air Weapons Range, Williamtown could not be completed before the deployment due to weather and aircraft unserviceability. The pilot was effectively night uncurrent, having only flown one night sortie in the past three months and had only logged 8.2 hrs night dual in the Hornet.*

## Accident summary

The sortie was a radar navigation sortie that terminated at White Rock, a small island off the south-eastern tip of Great Palm Island. From White Rock, which was used as the initial point (IP) for the bombing run, the students were to descend to 1000 ft and carry out a radar bombing pass on Cordelia Rocks, 15 nm to the south.

After the first pass, the aircraft were to commence a climbing left turn onto downwind for a further racetrack pattern and final bombing pass. The turn from downwind onto attack heading was to be commenced at 10 nm from the target. The briefing for the sortie included the directions to ensure clearance from Great Palm Island on ground map radar (on a 'standard' pass the aircraft would remain approximately 5 nm from the island) and to ensure that the aircraft had passed a westerly heading before commencing descent from 3000 ft AMSL to the run in height of 1000 ft AMSL.

One significant fact omitted from the brief, which was not known to the instructor (the brief was a standard brief prepared by someone else) or any of the students at the briefing, was that the pilot must abide by night VMC procedures once he had descended below safety height (the 1000 ft run-in to the target was below safety height).

The instructor completed the radar navigation exercise and bombing detail, and had performed RSO duties for the first student onto the range. Following that student's departure from the range, the instructor then orbited east of the target awaiting the incident pilot to enter the range. The incident pilot entered the range area, not from overhead the IP as expected, but on a direct track to the target from the previous turn point.

This error was almost certainly caused by incorrect use of the navigation system and was not detected by the instructor. The incident pilot then called approaching the IP and descending. On tracking to the next point (which should have been the target but was in fact the planned exit point from the range to the west) it became apparent to the incident pilot (and instructor who was completing an intercept on the student's aircraft) that a navigation error had occurred.

The pilot acknowledged the instructor's call to check that he had the correct waypoint set for the target, and then corrected the error and flew towards the target on a heading of 060° M. After tracking over the target, with the RSO in 1-1.5 nm radar trail, the incident pilot turned onto the briefed downwind heading of 020° M and climbed to 3000 ft.

Because the incident pilot had turned directly onto downwind on his 060° M approach, the downwind leg that the aircraft were on was some 4-5 nm west, and closer to Great Palm Island, than the standard downwind leg.

Contrary to the brief, which required the incident pilot to pass 270° M before descending onto the attack leg, he commenced an early descending left turn onto finals, levelling at 1000 ft and continued this left turn until the aircraft impacted the south eastern tip of Great Palm Island.

At the time of the crash, the aircraft was level, with 46° left bank and speed of approximately 460 kts. As the downwind leg had been flown intermittently in IMC, the RSO had been using the radar in air-to-air mode and was not monitoring the position of Great Palm Island on radar. During the final descent, having followed the incident aircraft around the turn using the air-to-air mode of the radar, the RSO became visual with the incident aircraft and switched his radar to air-to-ground mode.

This occurred only 3-4 seconds prior to impact and the RSO had insufficient time to interpret and warn the incident pilot of their proximity to Great Palm Island. The lack of either moonlight or man-made lighting precluded either pilot from visually acquiring Great Palm Island. On seeing the fireball of the incident aircraft directly ahead, the RSO immediately terminated his descent and climbed from 2000 ft AMSL (the highest

elevation on Great Palm Island is 1794 ft) and declared a mayday.

## Board findings

The Board made the following findings:

1. The primary cause of the accident was that the pilot descended below safety height without having established visual reference with the ground or water and without having fulfilled the requirements outlined in the pre-flight briefing, which would have ensured separation from Great Palm Island.
2. Aggravating conditions contributory to the accident were as follows:

**Bombing pattern design.** The bombing pattern design had little margin for error, which could reasonably occur given the pattern was to be flown by students with very little experience. The 1000 ft run in leg commenced in the vicinity of Great Palm Island (highest elevation of 1794 ft) and terminated in the vicinity of Magnetic Island (highest elevation of 1660 ft).<sup>51</sup>

**Non-standard pattern entry.** The incident pilot's non-standard entry to the application pattern, caused his downwind leg to be some 5 nm closer to Great Palm Island than the standard pattern should have been. Therefore, although the turn onto attack heading was close to the pre-briefed 10 nm distance from the target, the subsequent turn caused the incident aircraft to track over the south-eastern tip of the island.

**Night VMC requirement.** The requirement to adhere to the provisions of night VMC flight when flying the attack leg at 1000 ft AMSL was neither briefed nor understood by any of the 20CU staff deployed to Townsville at the time.

**Sub-optimum student-to-staff ratio.** The student-to-staff ratio at 20CU, which existed through the majority of the course meant that there was little time available for the staff to assess the content of sorties, or to question aspects of the syllabus, which had been handed down from past management.<sup>52</sup>

### Low experience levels of 20CU staff.

The recent introduction of the Hornet and pilot resignations resulted in an overall low experience level among 20CU instructors. Normally a more experienced staff member would have been programmed for RSO duties, and had this been the case, a more experienced AF/A-18 instructor may have identified the potential danger at an earlier stage.<sup>53</sup>

**Inadequate pre-flight brief.** The pre-flight brief was inadequate, taking into account the complex nature of the sortie and the variety of imponderables that could be encountered with students with low experience. One particular critical item that was omitted was the requirement to fly the attack heading in night VMC. The briefing slides, which had been in existence for a number of courses, presented a geographically inaccurate representation of the flight path for the bombing pattern that would have presented the students with a false impression of their actual flight path over the ground under ideal circumstances.<sup>54</sup>

**Lack of night currency.** The incident pilot had flown only one night sortie in the previous three months and the accident sortie was his first night solo ride in the AF/A-18.

3. Although the Board could not find any evidence that inertial navigation system (INS) data entry procedures were a factor in this accident, it became obvious that the practice existed of accepting the INS data without adequately cross-checking the accuracy of the data. As a number of overseas accidents have been directly attributed to the blind acceptance of entered INS data, the Board was of the opinion that a thorough verification of the entered data using the AF/A-18's slew function should be taught as a matter of course at 20CU.

## Recommendations

Board recommendations included:

1. Headquarters Operational Command direct 20CU to review in detail the sortie content of all AF/A-18 courses to ensure compliance with current orders and instructions.
2. The requirement to operate under night VMC be deleted from AF/A-18 conversion courses.
3. 20CU review the conversion phase with a view to inserting a night solo sortie prior to the commencement of the operational phases of the course.
4. The student-to-staff ratio at 20CU be maintained at no greater than one to one, excluding the CO and XO. Additionally, this ratio should be further reduced in times of particularly low experience levels among 20CU instructors.
5. The crashworthiness of the Maintenance Signal and Data Recording System (MSDRS) cartridge be improved and measures be implemented that will assist in locating the cartridge after an aircraft accident.

51. The RSO was to ensure the student pilot had identified the correct target and provide release clearance. There was no requirement for the RSO to monitor the student's position or flight parameters around the pattern.

52. None of the 20CU staff were aware how close the pattern went to Magnetic Island. If the pilot extended for 10 seconds past the target before commencing the left turn to downwind, the aircraft would impact Magnetic Island.

53. The less-than-normal student-to-staff ratio had been brought about by a number of 20CU instructors tendering their resignation from the RAAF and their subsequent grounding (the CAS had implemented a policy that pilots who had tendered their resignation were not to continue in active flying duties except with DEFAIR approval). Due to these manning shortfalls, the remaining 20CU instructors had a very high workload.

54. Of the nine 20CU instructors at the time, five – including the incident RSO/instructor – had only just graduated off the previous Hornet course in July 1987. Of the other four, two of those were exchange officers. (There were six students on the basic course and four students on the advanced course.) The AIT noted that instructor changeover (postings and resignations) at the time made it difficult to build corporate knowledge, which likely contributed to the adoption of unsafe practices such as flying the range pattern in IMC and below safety height.

55. The slides indicated more clearance from Magnetic Island than was the case – the depicted bank angle was closer to 60° than the typical 30–40° that would have been used for the off-target turn onto downwind.



6. The light used on top of Cordelia Rock for night bombing be upgraded so that it is clearly visible when flying at or above 3000 ft.
7. Headquarters Operational Command arrange for a more precise definition of the night VMC requirements pertaining to visual reference in the Flight Planning (FLIP) manuals and associated publications.

## Changes attributable to this accident

Changes to AF/A-18 procedures and aircraft modifications that were more than likely influenced by this accident are:

1. The RAAF AF/A-18 Hornet courses are regularly reviewed, particularly following major upgrades and introduction of new capabilities, to comply with current orders and instructions, tactical procedures, domestic procedures and restrictions.
2. No Hornet course sortie involves night visual flight rules (VFR) operations. Additionally, the RAAF no longer operates the Hornet below minimum safe altitude (MSA) at night.
3. The first student night solo sortie on the Hornet conversion course is during the air-to-air phase – there is no night solo during the conversion phase – and all night air-to-air missions are flown above

a 5000 ft hard deck. The follow-on air-to-surface phase is focused on sensor attacks and precision guided munitions, with all operations conducted above MSA/lowest safe altitude (LSALT). The first two night missions on the air-to-surface phase are dual missions and subsequent night sorties involve medium altitude attacks, well above MSA.

4. 20CU works to a higher number of instructors than students (the minimum student-to-staff ratio equates to two staff per student for the first six students and one staff member per additional student).
5. 20CU students are taught to cross-check navigation data prior to taxi by using the slew switch to check turnpoints and routing via the moving map. Additionally, the initial point and target data is cross-checked against the most 'removed' mission planning product available (i.e. not kneepad cards but intelligence target imagery if available).

**Below: Felled trees looking back along flightpath on Great Palm Island – aircraft A21-104.**



# Mid-air collision near Tindal, 02 August 1990, (AF/A-18 A21-42)

**W**hile conducting a day air-to-air mission to the northwest of RAAF Base Tindal, Northern Territory, the lead aircraft (A21-42) collided with the wingman killing the lead pilot instantly. Although damaged, the pilot of the second aircraft (A21-29) was able to land the aircraft successfully. The lead aircraft crashed into the ground and was destroyed.

The two aircraft were part of an AF/A-18 4V4 air combat tactics (ACT) and conjoint operations mission with USAF B-1 aircraft. The incident aircraft were the second pair (N° 3 and N° 4) of the fourship escort/sweep formation. The opposing fourship was providing vital area defence (VAD) overhead Tindal. Weather conditions were not a causal factor in the accident, with good visibility and a clear sky.

## Crew

Pilot (A21-42): Cat B – 3300 hrs total time / 947.7 hrs AF/A-18; current [aviation medicine (AVMED) training uncurrent]

Pilot (A21-29): Cat D – 682.8 hrs total time / 106.7 hrs AF/A-18; current (to safely operate the aircraft)

*Note: The pilot of A21-29 was not sufficiently experienced to participate in the incident sortie. He had only just completed the Hornet Operational Conversion Course and had not completed a suitable tactics work-up program for the ACT/conjoint operations program.*

## Accident summary

During the week of the accident, the squadron had planned to conduct a relatively light flying program due to limited availability of experienced pilots<sup>56</sup> and the recent arrival

of four Category D pilots who had just completed Hornet Operational Conversion Course.

However, the planned training program of 2V4 missions was amended to 4V4 ACT and conjoint operations to accommodate a request from a USAF B-1 detachment. The program change was not expected and the squadron was not prepared for 4V4 conjoint operations. The absence of the experienced aircrew required inclusion of the Category D pilots in the program. To make allowance for their lack of experience, the fourships were flown as separate two-ship elements.

As a consequence of the limited time available before the commencement of the amended program, and the belief that the planned missions were simply an extension of the Pitch Black missions that the squadron had just conducted, preparatory briefings were minimal.

The Category D pilots, who had not flown in the Pitch Black missions, were only given an informal mass brief two days before the accident sortie. For the incident mission, a mission brief was conducted, followed by individual formation briefings by the two formation leaders; however, no element briefing occurred between the accident pilots.<sup>57</sup>

The initial part of the sortie was conducted in accordance with the attackers' formation gameplan. After several engagements with the defending VAD section, during which 'kill removal' reduced the remaining participants to the lead pair of the VAD section and the second (incident) pair of the escort/sweep section, the depleted escort/sweep section initiated a further engagement on the remaining defenders.

At the beginning of this engagement the attacking incident pair were established virtually co-altitude in a close spread (i.e. line abreast) formation with 3000-4000 ft of lateral separation.<sup>58</sup> The N° 3 was on the left.

When radar contact with the VAD section was established, the attackers effected a relatively hurried (simulated) missile launch, at which point the N° 3 aircraft called a tactical turn (F-pole) to the right.<sup>59</sup>

The N° 4 aircraft had completed approximately 26° of this turn when the two aircraft collided. The left wing of the N° 4 aircraft impacted the cockpit area of the N° 3, killing the pilot instantly. Wreckage analysis indicated that both aircraft were in virtually the same attitude in pitch and roll and were converging in yaw by approximately 10 degrees. N° 3 was slightly overtaking N° 4 and closing on him from above.

The N° 4 pilot had felt a thump on impact and recovered to straight and level flight, observed the damage to his left wing and horizontal stabiliser and then saw the N° 3 aircraft in his 5 o'clock position approximately 1000 ft away, slightly low, with about 30° heading difference and approximately 40° angle of right bank. The N° 3 aircraft continued to descend in a right turn away from N° 4, with fire and smoke issuing from the dorsal area behind the cockpit which obscured the cockpit area.

The N° 3 aircraft was then observed to crash to the ground where it exploded on impact. The N° 4 aircraft, following a visual inspection from another AF/A-18 aircraft, was safely recovered to Tindal despite the extensive damage.

56. At the end of the week before the accident, five Category B pilots departed the squadron to commence Fighter Combat Instructor (FCI) training and two middle-level experienced pilots were required to ferry aircraft to Williamtown for scheduled aircraft maintenance. The XO was also absent on approved leave.

57. The lead accident pilot had to attend a base conference prior to the briefings, and with the subsequent bringing forward of the mission briefing and sortie timelines, was unable to attend either the mission brief or formation brief. However, the formation lead did provide a separate, short-duration brief for the lead accident pilot prior to aircraft maintenance release.

58. Separation had been reduced for tactical considerations, as had the decision to fly without an altitude separation.



## Board findings

The Board made the following findings:

1. The primary cause of the accident was that the lead pilot failed to take adequate collision avoidance action while executing a turn towards his wingman, resulting in a mid-air collision.
2. Contributory causes included:
  - a. The most likely cause of failure to take collision avoidance action was an error of judgement on the part of the lead pilot in failing to comply with the correct procedure of establishing and maintaining visual contact sufficient to avoid a collision with the other aircraft
  - b. Distraction from the task of collision avoidance due to pre-occupation with the tactical situation on the part of the lead pilot during his execution of the F-pole manoeuvre.
  - c. The inexperience of the wingman and the high workload he found himself in, precluded him from exercising his own collision avoidance precautions even though he (correctly) believed that his leader had prime responsibility for collision avoidance during the manoeuvre.
  - d. The lead pilot was suffering the effects of chronic fatigue.<sup>60</sup>

## Recommendations

Board recommendations included:

1. The intricacies of collision avoidance responsibilities and the dangers of task pre-occupation in high-workload situations be stringently examined with a view to promulgating guidance concerning specific responsibilities for each formation member.
2. Education programs concerning the factors contributing to fatigue and the effects of fatigue continue to be emphasised to aircrew and flying supervisors.
3. The Hornet Pilot Categorisation Scheme (CATSCHEME) be amended to more stringently regulate the progression of

Below: Collision damage to wingman's aircraft – aircraft A21-29.



59. Aircraft separation had been further reduced by N° 4's gentle turn to the left to achieve his shot before commencing a smooth right turn in response to lead's F-pole call. The N° 3 pilot also had a habit of rolling his aircraft in anticipation of the turn prior to calling his missile shot and subsequent F-pole turn. While N° 4 did respond to the F-pole call, a lack of standardisation was noted by the investigation team in that some aircrew thought an F-pole call was advisory rather than executive (directive). The F-pole manoeuvre attempts to maximise the distance between the launch aircraft and the target at missile impact, while maintaining radar contact and hence designation of the target for missile guidance.

60. There was evidence that the pilot was suffering the effects of chronic fatigue due to workload and dedication to duty. Additionally, he had only just recovered from a medical condition known to have fatigue as a side effect.

Category D Hornets pilots through the CATSCHEME events.

4. The CATSCHEME review also address a more positive regulation of the progression of other Hornet pilots through the CATSCHEME events.
5. The policy regarding carriage of passengers by Category D Hornet pilots on operational training sorties be reviewed.<sup>61</sup>
6. The crashworthiness of the MSDRS be improved.
7. Information regarding the risks associated with the presence of composite materials in aircraft accidents be immediately and widely disseminated throughout the RAAF.<sup>62</sup>

## Changes attributable to this accident

Changes to AF/A-18 procedures and aircraft modifications that were more than likely influenced by this accident are:

1. Formation and collision avoidance procedures were reviewed and redefined. The original adage of four avoids three avoids two avoids one was updated to discuss collision avoidance responsibility in specific arenas, especially during tactical turns and tactical manoeuvres. It is commonplace now for wingmen to call "blind" in a similar situation that arose in this incident, where the lead disappears underneath the airframe during tactical turns or manoeuvres. The lead will call "visual" or "press" to indicate a temporary change of collision avoidance responsibilities, and wingmen calling "visual" once again to resume standard collision avoidance responsibilities.
2. AF/A-18 category D pilot postings from 20CU have been more evenly distributed throughout the three operational squadrons, ensuring (in)experience is spread more evenly throughout the force.
3. While not directly attributable to this accident alone, 81WG Hornet Standard Operating Procedures (HSOPS) have been amended to provide specific guidance on carriage of passengers. This amendment included the following:
  - a. Category D pilots prevented from carrying passengers.
  - b. Mission leads, irrespective of category, prevented from carrying passengers. This change was designed to ensure the formation lead, the individual likely to be

under the highest airborne workload, was not further stressed by carrying a passenger.

- c. Specific guidance on briefing requirements for all passengers.
4. Hornet crash recovery kits include protective clothing, and all maintenance personnel are briefed on the dangerous materials associated with the Hornet.
5. Category D pilot participation in more complex exercises (such as Pitch Black

or a Bersama series) is more seriously considered and their inclusion in such exercises is now not commonplace.

6. The Hornet CATSCHEME was eventually reviewed. While not directly related to this accident, a new category of C2 was introduced (combat ready wingman) and this category is the absolute minimum required for participation in more complex exercises or events.



Above: Main wreckage (the nose and a portion of the cockpit had separated in flight - aircraft A21-42.

Below: Carbon fibre hazard - aircraft A21-42.



61. The N° 2 (D Cat) pilot had a USAF B-1 pilot in the rear seat. This passenger assisted in the avoidance of a mid-air collision of similar circumstances to the other element, by alerting the pilot of the high rate of closure with N° 1 as they unknowingly turned towards each other. The miss distance was less than 100 ft.

62. During the initial response to the accident site, two of the attending personnel removed some of their personal protective equipment (respirator) for a short period and unwittingly exposed themselves to the dangers associated with carbon fibre.



# Pilot incapacitation near Tindal,

## 05 June 1991,

### (AF/A-18 A21-41)

**D**uring the climb to high level for the return to RAAF Base Tindal, the pilot became incapacitated to such an extent that he could not control the aircraft and the aircraft continued under autopilot control.

The aircraft was tracked by another Hornet aircraft and Tindal radar until 250 nm east-northeast of Tindal where it was last observed maintaining a constant heading and a slight climb. An extensive air and sea search at the time failed to locate the pilot or the aircraft.<sup>63</sup>

The incident pilot was the lead of a pair of Hornets conducting a day HI-LO-HI simulated strike on a target approximately 250 nm southwest of Tindal.

## Crew

Pilot: Cat C – 863.8 hrs total time/  
254.4 hrs AF/A-18; current (AVMED uncurrent)

## Accident summary

The flight proceeded uneventfully for the first leg, which included a climb to FL305 – level flight for approximately 20 seconds – and a descent to low level. Following the low level segment and target attack, the formation commenced a climb to a planned altitude of FL330 for the return to Tindal.

The incident pilot made a normal radio call passing FL220 and, for an unknown reason, levelled at FL280 for one minute

before resuming climb. The pilot failed to level off at FL330. Passing FL369 the pilot did not acknowledge radio transmissions from the wingman or ATC, and between FL370 and FL390 the wingman saw, for the first time, that the pilot was slumped forward with his oxygen mask off.

The wingman remained with the lead aircraft until his low fuel state forced him to return to Tindal. The incident pilot did not respond to the numerous radio transmissions by the wingman or ATC. The incident aircraft was last observed at the limits of Tindal's radar, still tracking 073°, climbing through FL460. It was presumed that the aircraft then continued to a point 073° M Tindal at approximately 600 nm (60 nm north-northeast of Weipa, Queensland), ran out of fuel, and crashed, killing the pilot.

During the investigation it was found that maintenance personnel had conducted an engine ground run on the incident aircraft the day before the accident. At completion of the ground run, the aircraft was shut down in accordance with maintenance checklist publications.

The environmental control system (ECS) mode and cabin pressure switches were left in the AUTO and DUMP positions respectively. While the incident pilot should have checked and repositioned the cabin pressure switch to NORM during his pre-start checks, it is possible that he did not.<sup>64</sup>

If the incident pilot had in fact not realised the cabin pressure switch was incorrectly set to DUMP, the cabin would have been unpressurised and the pilot, on removing his mask at altitude, would have quickly suffered hypoxic hypoxia due to the lack of cabin oxygen.

With the lack of AF/A-18 cautions or warnings associated with abnormal cabin pressure values or limitations, and the poor ergonomic location of the cockpit pressure altitude gauge (on the centre console between the pilot's legs), the incident pilot would not have been provided any additional cues of the unsafe situation. (During a subsequent trial flight with ECS in AUTO and cabin pressure switch in DUMP, the trial pilot reported that noise level in the cockpit was only slightly more than with the cabin pressure switch in NORM, and similarly cockpit temperatures were not sufficiently different to provide the pilot cues that an incorrect switch selection existed.)

## Board findings

The Board made the following findings:

1. The primary cause of the accident could not be determined.
2. The most likely causal factor was deemed to be that the pilot suffered hypoxic hypoxia, as a result of removing his oxygen mask in an unpressurised cockpit at altitudes greater than 28,000 ft.<sup>65</sup>

63. The aircraft wreckage and pilot remains were eventually found in July 1994, approximately 60 nm northeast of Weipa, Queensland.

64. Discussions with 75SQN pilots during the course of the inquiry revealed that most of them had inadvertently taken off with the cabin pressure switch selected to DUMP, some on more than one occasion. The error was usually discovered when the pilot became suspicious due to worse-than-normal trapped body gas problems during the climb, a general feeling of being unwell (hypoxia symptoms?), or the onset of pressure breathing as they climbed through approximately FL300. One of the squadron pilots also admitted to a non-standard procedure of dealing with AV AIR HOT cautions on the ground by selecting DUMP on the cabin pressure switch. Such a practice increases the possibility of the switch being inadvertently left in the DUMP position after engine shutdown.

65. The incident pilot had a history of flying with his oxygen mask removed. As recently as two days before the accident, the incident pilot had indicated to another squadron pilot that he considered it unnecessary to wear his oxygen mask at altitudes around 30,000 ft since the cabin altitude was only about 12,000 ft under those circumstances. (With the cabin pressure switch set to NORM, the AF/A-18 cabin pressure schedule maintains a cockpit altitude of approximately 8000 ft until 23,000 ft aircraft altitude. Above 23,000 ft aircraft altitude, the cockpit altitude increases slowly to approximately 14,500 ft at 35,000 ft aircraft altitude, and 20,000 ft at 50,000 ft aircraft altitude.) The Board concluded that since a radio call had been made passing FL220, the incident pilot must have taken his oxygen mask off some time later, probably when he unexplainably levelled off at FL280 for a short period during the climb. (The time of useful consciousness at FL280 is less than two minutes and time to unconsciousness is less than four minutes. These times decrease with increasing altitude.)

A second possible causal factor was that the pilot could have suffered a heart attack due to a pre-existing medical condition.

## Recommendations

Board recommendations included:

1. Action be taken to develop and install a cabin pressurisation warning system in the Hornet. The warning system should provide the following:
  - a. An aural warning (master caution tone) and digital data indicator (DDI) caution (for example CAB ALT) to be generated when cabin altitude exceeds 20,000 ft with the cabin pressure switch selected to NORM and the ECS mode switch selected to AUTO or MAN.
  - b. An aural warning (master caution tone) and DDI caution (for example CAB ALT) to be generated when cabin altitude exceeds 10,000 ft, if aircraft pressurisation is inoperative due to the cabin pressure switch being selected to DUMP or RAM/DUMP, the ECS mode switch being selected to OFF/RAM or BLEED AIR being selected OFF.
2. The Installed Engine Run checklist used by maintenance personnel be amended to include all relevant cockpit switch selections for pre-, during and post-engine run conditions as detailed in other associated AF/A-18 maintenance manuals.<sup>66</sup>
3. Action be taken to develop and install a positive oxygen flow indicator, coupled with an aural warning should oxygen flow be interrupted for a period of time.
4. Crash locator beacons with underwater capability be installed in all RAAF Hornet aircraft.
5. Restructure initial ADF AVMED training for fast-jet streamed aircrew to provide more frequent training early in the aircrew's

career to reinforce the lessons learnt and build safe habit patterns.<sup>67</sup>

## Changes attributable to this accident

Changes to AF/A-18 procedures and aircraft modifications that were more than likely influenced by this accident are:

1. Incorporation of a RAAF-unique oxygen flow caution (OXY FLOW) to prevent pilot incapacitation due to oxygen starvation. An OXY FLOW caution and master caution light illuminate and the master caution tone sounds for a number of conditions below and above 10,000 ft including when the pilot's mask is off or incorrectly fitted, the oxygen hose is disconnected, there is a continual leak within the oxygen system, or the mask is fitted but no breath has been taken within 15 seconds.

**Below: Wreckage recovery – aircraft A21-41.**

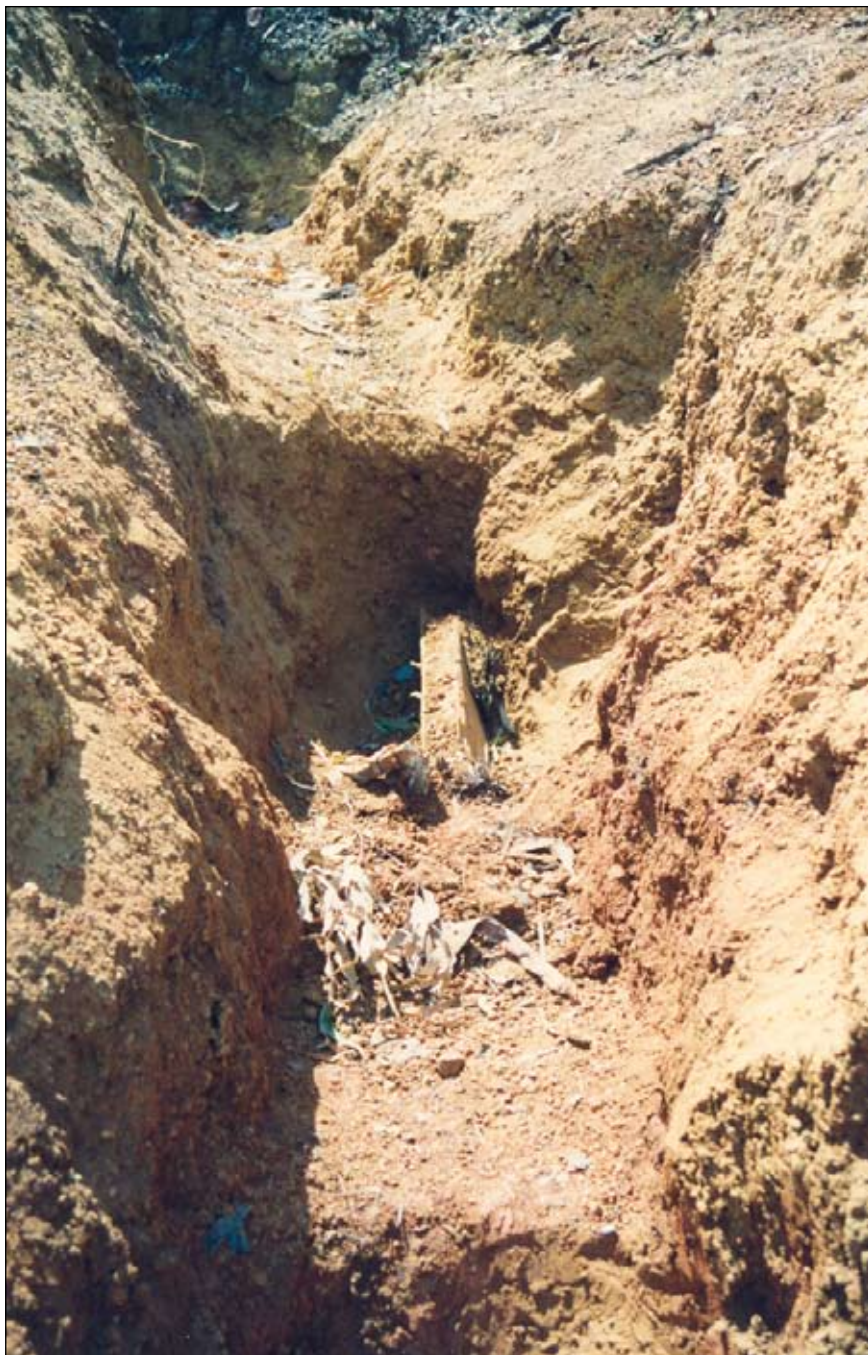


66. Maintenance servicing publications dealing with engine ground runs were deficient. One publication called for the cabin pressure switch to be selected to DUMP prior to engine runs. Post-engine run switch selections were covered in two different publications. One (US Navy sourced) specified clearly exact switch selections, including cabin pressure switch to NORM. The second (RAAF sourced) simply stated to set the cockpit switches to the 'power off position'. As a result, many maintenance personnel were unaware of the specific switch selections required to be set after engine runs and left the cabin pressure switch in the DUMP position.

67. It was thought, that since the incident pilot had only completed AVMED training once (during his initial pilot training and four years prior to the accident) that he may have had insufficient experience to be fully aware of his individual hypoxia symptoms. At the time of the accident he was 11 months overdue for his AVMED refresher training.



2. Incorporation of an oxygen delivery warning system (ODWS) fitted to AF/A-18A (single-seat aircraft only) to inform the pilot of failures within the oxygen delivery system. The OXY FLOW caution and master caution light illuminate and the master caution tone sounds when a continuous oxygen flow is detected for more than 15 seconds, or no flow is detected for more than 30 seconds at cabin altitudes above 10,000 ft.
3. Incorporation of an ECS switch caution light (ECS SW) advisory to inform the pilot that one or more of the ECS switches are in an incorrect position to pressurise the cabin. The ECS SW caution and master caution light illuminate and the master caution tone sounds when the aircraft is above 10,000 ft and the bleed air knob is selected to off, the mode switch is selected to OFF/RAM, or the cabin pressurisation switch is selected to DUMP or RAM/DUMP.
4. Incorporation of a cabin altitude caution light (CAB ALT) advisory to inform the pilot that cockpit altitude has increased to above 22,000 ft. The CAB ALT caution activates the master caution light and master caution tone.
5. Introduction and reinforcement of climb and 'Ten Minute' checks where the pilot checks the oxygen contents and connections and ensures the cabin altimeter is on schedule when passing 10,000 ft, on level-off and during the mission.
6. Incorporation of a crash-survivable recording device (voice and data recorder) in AF/A-18 aircraft to assist with accident investigations.
7. Maintenance engine run procedures were changed to ensure that the cockpit switches were left in the appropriate position for flight - ECS mode switch in AUTO and the cabin pressurisation switch in NORM.



Above: Wing recovery – aircraft A21-41.





Above: Wreckage examination – aircraft A21-41.



Above: Wreckage pile – aircraft A21-41.

# Ground impact Shoalwater Bay, 19 May 1992, (AF/A-18 A21-106)

**D**uring the post-weapon delivery egress at low level, the aircraft impacted a 200 ft high ridge and was completely destroyed by the impact and subsequent explosion. Both occupants were killed.

The accident aircraft was the second aircraft of a two aircraft section that was part of a composite package of RAAF AF/A-18, F-111C and RNZAF A4-K aircraft participating in an Exercise in the Shoalwater Bay Training Area (SWBTA), Queensland. Weather in the target area at the time of the accident included cloud cover varying between seven and eight octas with a base between 1200-1500 ft AMSL and tops at 2500 ft AMSL.

## Crew

Pilot: Cat C - 980 hrs total time / 236 hrs AF/A-18; current

Passenger: Defence Science and Technology Organisation (DSTO) scientist; four previous Hornet flights<sup>68</sup>

## Accident summary

The accident mission was tasked the day prior to the accident, thereby providing ample planning time. The accident pilot's involvement in the overall operational planning of the mission was minimal as his time was primarily devoted to refamiliarising his passenger with the Hornet and back-seat requirements. The briefed tactics for the target area was that at the pre-planned point, aircraft would split for individual attack profiles, with the actual profile used dependent on weather suitability.

The primary profile was for a high-angle pass from medium altitude. The secondary option was to conduct a 25° pop/10° dive with weapon release altitude of 2300 ft AMSL (the profile required a minimum cloud base of 3000 ft AMSL). A tertiary option was to conduct a level delivery at 650 ft AMSL (the profile required a minimum cloud base of 1150 ft AMSL). The wingman was to exercise his own judgement as to the suitability of the weather for the secondary profile.

In the event of a tertiary pass, the wingman was not to release weapons. If cloud was entered at any time, the plan was to penetrate wings level, until established 'on top'.

After take-off, the mission proceeded as planned and without incident until some 45 seconds before impact. At this point, while ingressing at 250 ft ASL, the accident aircraft had turned away from lead to set up for an individual weapons pass (the primary profile was not an option due to weather) as dictated by the prevailing weather conditions and planned release parameters. During the run-in, lead communicated his intention to conduct the tertiary-level pass, which the accident pilot acknowledged.

Accident reconstruction indicates that the accident pilot did not pull up at the nominated pop point for the secondary profile but conducted an unbriefed and unpractised weapon delivery on the unfamiliar but vertically significant target. The actual profile used could be best described as a non-standard toss delivery profile (executed from 1280 ft AGL/440 kts

rather than the documented 250 ft AGL/540 kts run-in parameters for an AF/A-18 toss profile).

As a result, the aircraft likely entered cloud with a high rate of climb. In an effort to regain visual with the lead aircraft, the accident pilot then commenced a hard descending manoeuvre, penetrating below safety height and probably through cloud. On breaking clear of cloud<sup>69</sup> at 1500 ft in a very nose-low attitude (estimated in the region of 30-40°) and with insufficient altitude to recover, impact with the ground was inevitable – post crash analysis indicated that the aircraft impacted the ground at a 25-30° nose-down attitude, 450 kts, wings level, idle power and with 6.9 G applied.

## Board findings

The Board made the following findings:

1. The primary cause of the accident could not be determined.
2. The most probable cause was, that for reasons unknown, the pilot initiated a controlled flight path, or experienced uncontrolled flight, that placed the aircraft in a turning descending attitude, in cloud, from which recovery was not possible with the height and time remaining.

## TFG and ACAUST comments

Commander Tactical Fighter Group (TFG) and ACAUST concluded that likely contributory causes, in order of importance, were:

- a. the pilot's disregard of the briefed emergency actions for recovery from an

68. The accident flight was the first of a series of AF/A-18 rides planned to further assist the Defence scientist's work on an air combat modelling task.

69. The lead pilot, having manoeuvred his aircraft to watch his own bombs impact, observed the accident aircraft in a position consistent with the briefed post target egress plan. A few seconds later he observed a fireball some 2 km east of the target, and, when the wingman did not respond to a subsequent radio check, assumed that the fireball was as a result of the wingman's aircraft exploding on impact with the ground.



aircraft entry into cloud below safety height<sup>70</sup>,

- b. the pilot's failure to ensure that while in the target area, cloud was avoided at all times,
- c. the pilot's disregard of the briefed release parameters for a secondary pass,
- d. possible confusion regarding the degree of discretion permitted to the pilot should his leader nominate a tertiary pass, and
- e. the pilot's low experience in Hornet operations.

A potential contributing cause was determined to be the pilot's perceived pressure to achieve a good sortie result following his performance on the previous day, which was marred by an entry-into-cloud incident.

## Recommendations

Board recommendations included:

1. Weapon passes involving 'pop' procedures be terminated at, or before, the planned pop point if any doubt exists that the pass cannot be prosecuted in accordance with the planned profile.
2. The publications dealing with hazardous materials at Hornet accident sites be reviewed and updated.
3. Trained and qualified medical officers be provided at bases supporting Hornet deployments. (The Air Commander also directed that Base Standing Orders of Air Command Bases be amended to include the requirement for a medical officer to attend an accident site.)<sup>71</sup>

## Changes attributable to this accident

Changes to AF/A-18 procedures and aircraft modifications that were more

than likely influenced by this accident are:

1. The Defence Safety Manual lists the hazardous materials for each ADF aircraft type and details the hazards and precautions that must be taken at accident sites.
2. The HSOPS provide specific guidance on briefing and execution requirements for air-to-surface attacks as follows:

**Briefing.** The pre-flight briefing is to cover weather minima required for the profile and a defined point in space or time, and/or procedure, by which the mission lead decides whether the attack will be continued or a secondary attack is conducted (for example, the high/low show decision will be made no later than 10 nm prior to the initial point and more than two octas of cloud below 7000 ft AMSL will require the secondary attack to be flown).

**Execution.** During any pass, at or after roll-in, the aircraft must be maintained in VMC and an unobscured line of sight to the target must be maintained until after weapon release/recovery.

The recovery must still be flown in order to meet any other pass design requirements (for example, weapon fragmentation avoidance, terrain clearance, deconfliction) as appropriate. If IMC is encountered post roll-in, the pass must be aborted and the aircraft recovered immediately to safety height.

3. A maximum number of attacks to be planned and briefed per mission was established. This included no more than three attacks to be briefed for any mission, and for complex strike missions, only two attack options to be briefed.



Above: Crash site at Shoalwater Bay Training Area – aircraft A21-106.

Below: Stabiliser – aircraft A21-106.



70. In the course of the investigation, two instances of low-altitude penetration of cloud were noted in the accident pilot's history. The first instance occurred as a student on Introductory Fighter Course where, having inadvertently entered cloud during the conduct of a dual application bombing mission, he descended wings level through cloud to regain visual with the other aircraft. The second incident occurred on the morning prior to the accident when the accident pilot lost sight of the lead aircraft and elected to penetrate on top to eliminate the collision risk. In doing so, the accident pilot had penetrated the simulated fragmentation envelope. The second incident was subject of discussion during the subsequent debrief.

71. For the incident squadron's deployment to Townsville, the only medical officer on staff was a RAAF Reserve medical officer on relief manning as Senior Medical Officer (SMO). This member had no AVMED qualifications or training and was inexperienced in SAR and helicopter operations. Consequently, the senior nursing officer was the only medical person to respond to the SAR and attend the accident site.

# SUMMARY

The investigations into each of the accidents (summarised in the following table) revealed a number of conditions that contributed to the final outcome as per the four elements of Reason's concept of the organisational accident. Some of these conditions are as follows:

**Organisational or latent conditions.** Contributory managerial policies and actions included inadequate or deficient policies and orders, and inaction or flawed processes in ensuring aircrew and maintenance reference publications were adequate and current.<sup>72</sup> Lack of inspection programs or investigations into known aircraft-system problems, slowness in implementing aircraft modifications, not providing suitable training or training devices (for example, F-111G simulator), and acceptance of low numbers of experienced instructors without a commensurate reduction in tempo or training throughput were also contributory in some of the accidents. Operations from runways where a successful abort could not be accomplished was also an inadvertently accepted practice.

**Local (workplace) factors.** Contributory task and environmental conditions included task unsuitability (for example, using the F-111G for simulated Harpoon employment, or flying the simulated Harpoon missile flightpath), low aircrew experience, lack of proficiency or currency in assigned tasks, low simulator or aircraft availability, lack of work-up training, and marginal weather conditions (including insufficient visibility to ensure terrain clearance). Poor ergonomic design of cockpit controls and displays, inadequate operating environments (for example, lack of suitable aircraft arresting systems, poor runway drainage resulting in excessive water pooling), high operational tempo, and priority of secondary duties resulting in inadequate aircrew focus on the mission at hand, were also contributory in some of the accidents. Pre-existing medical conditions and life stressors of some of the aircrew may also have contributed to active failures.

**Active failures.** Unsafe acts that were inadvertently conducted by some of the crew included inadequate

mission planning and briefing, using outdated or uncurrent planning data, failure to conduct aircraft pre-flight checks accurately, not checking cable/runway status, utilising inadequate take-off data, attempting to conduct a take-off in unsafe conditions, not analysing complete aircraft conditions during incident analysis, and aborting above refusal speed. Failures that were contributory to the accidents that could be classified as CFIT included initiating descent below safety height without ensuring positive terrain clearance, attempting to conduct unsafe descent profiles, failure to identify enroute terrain hazards, not using all available aircraft systems to ensure terrain clearance, failure to engage/disengage aircraft systems, navigation errors, inadequate instrument scan and interpretation, and poor cockpit workload assignment and task prioritisation (including failure to fly the aircraft as the primary concern). Failure to wear all available aircrew safety equipment, and failure to observe flight-manual warnings and cautions were also contributory in some of the accidents.

**Inadequate or absent defences.** Defences that failed to protect against technical and human failures included inadequate or flawed orders, instructions, standard operating procedures, normal and emergency procedures, maintenance practices and procedures, inadequate supervision or oversight, and failed currency tracking and reporting procedures (crew currency in the planned events not readily available to crews, supervisors and flight authorisers). Insufficient/no work-up training, crews not involving themselves in the mission-planning process or failing to voice their concerns with the plan during mission planning, briefing or execution, and lack of external review for self-authorised missions were also contributory. Other failed defences included inadequate processes for route survey to identify hazards and obstacles and route suitability for low-level flight, absence of processes for official sanction of new tactics, lack of suitable warnings and cues of unsafe aircraft situations (for example AF/A-18 cockpit pressurisation) because of aircraft design and ergonomics, and lack of standardisation in crew techniques for execution of procedures (for example, flight profile, instrument scan and crew cross-talk during tactic execution). Formal aviation risk management processes were also non-existent at the time of all of the accidents.

72. Deficiencies in RAAF publications were causal in a number of the accidents and were brought about by these publications lacking the detail contained within the equivalent USAF/USN publications.



Serial	Date	Type	Tail N°	Fatal	Time	Environment	Segment	Current	Likely Cause
1	28 Apr 77	F-111C	A8-136	No	Day	Land	Cruise	Yes	Material (fire)
2	29 Sep 77	F-111C	A8-133	Yes	Day	Land	Target	Yes (pilot limited experience)	Environment (birdstrike)
3	25 Oct 78	F-111C	A8-141	No	Day	Maritime	Target	Yes	Material (fire)
4	24 Aug 79	F-111C	A8-137	No	Day	Land	Take-off	Yes (pilot limited experience)	Human (late abort)
5	28 Jan 86	F-111C	A8-139	Yes	Night	Maritime	Target	No	Human (CFIT)
6	02 Apr 87	F-111C	A8-128	Yes	Night	Land	Target	Yes (limited experience)	Human (CFIT)
7	13 Sep 93	F-111C	A8-127	Yes	Night	Land	Target	No	Human (CFIT)
8	18 Apr 99	F-111G	A8-291	Yes	Night	Maritime	Target	Yes	Human (CFIT)
9	18 Nov 87	AF/A-18	A21-104	Yes	Night	Land	Target	No (limited experience)	Human (CFIT)
10	02 Aug 90	AF/A-18	A21-42	Yes	Day	Land	Target (air-to-air)	Yes (AVMED uncurrent)	Human (collision)
11	05 Jun 91	AF/A-18	A21-41	Yes	Day	Land	Cruise	Yes (AVMED uncurrent)	Human (aeromedical)
12	19 May 92	AF/A-18	A21-106	Yes	Day	Land	Target	Yes (limited experience)	Human (CFIT)

Table 1. Summary of RAAF F-111 and AF/A-18 accidents

# CONCLUSION

Nearly all of the RAAF F-111 and AF/A-18 fatal accidents that have occurred to date can be attributed to some extent to crews not being fully aware of the situation or the environment around them.

Four of the five F-111 and two of the four AF/A-18 fatal accidents could be classified as CFIT – these CFIT accidents (apart from one of the AF/A-18 accidents) were at night. Additionally, all of these accidents have been in the target area (or area of engagement). This is where crew workload is at its highest level, and in the case of multi-crewed aircraft, where crew communication and co-ordination tends to break down.

Any distraction, or the planned events not going as expected, can have dire consequences, particularly when operating close to the ground where there is little margin for error. Two of the F-111 fatal accidents were during the weapon delivery profile, where the aircraft was being dynamically manoeuvred with reference to flight instruments. In these instances, the crews, for reasons unknown, were unable to comprehend the rate of closure with terrain.

Currency, or lack thereof, was also a factor in many of the accidents. Ensuring crews are current and proficient to conduct the sortie should not be the sole responsibility of supervisors and flight authorisers. The individual should also be accountable. Only the individual can truly know their comfort level in conducting the planned event.

If currency (and proficiency) is low, then that is the time to take it a little easier and simplify the

plan as much as possible. It is not the time to pull out the superior but perhaps more complex tactic, and certainly not the time to try something new.

So, what can we learn from the situations and tragic outcomes that these crews found themselves in?

Is it that we should not take any sortie for granted, no matter how simple it may appear? We should therefore, for every sortie we fly in, be intimately involved in the planning process enabling the combined talents to come up with the best and safest plan. If we have doubts about the plan, then we should speak up as that is all that it may take to break the causal-factor chain and achieve the required corrective action.

Is it that we should conduct regular critical reviews of the way we do business so that we can identify elements of unnecessary risk and find potentially better ways of doing business?

Is it that we must all be aware of our currency, or lack thereof, and to achieve the required currency safely, use the flight simulator or at least ensure you are day current in the event before attempting the event at night. It would be prudent to be aware of circumstances where currency will be low, such as periods of continued low aircraft availability.

Is it to be aware of the distractions that may dull your performance such as personal life stressors or fatigue?

Or maybe the message can simply be put as has been said before “train like you would fight but make sure you get to the fight”.

After all, when did Australia last lose an aircraft due to enemy action?



