RESTRICTED
STAFF-IN-CONFIDENCE

CAF 06/1180999 Pt 2 (2)

DIRECTORATE OF DEFENCE AVIATION AND AIR FORCE SAFETY

AIRCRAFT ACCIDENT INVESTIGATION REPORT

LOSS OF BLACK HAWK A25-221
EMBARKED IN HMAS KANIMBLA, NEAR FIJI
29 NOV 06

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MANDATE OF DDAAFS

FOR ACCIDENT INVESTIGATIONS

In 1997, the Minister for Defence directed the establishment of an Australian Defence Force (ADF) Flying Safety Organisation operating under the authority and guidance of the Chief of Air Force (CAF). The Directorate of Defence Aviation and Air Force Safety (DDAAFS-formerly the Directorate of Flying Safety—Australian Defence Force) coordinates and advises the Service Chiefs on flying safety issues relevant to their respective Service recognising that flying safety remains a Command responsibility within the individual Services. In all military organisations, clear chains of command and hence responsibility, allow achievement of objectives in both peace and war. The ADF can only meet its aviation safety objectives with a well-defined aviation safety organisation with clear responsibilities.

DDAAFS advises the individual Services regarding accident investigation and reporting. Actioning of DDAAFS accident investigation and reporting recommendations remains a single Service matter. DDAAFS is staffed with trained air safety investigators, working under the command of the Director.

All ADF aircraft accidents are independently investigated by an Aircraft Accident Investigation Team (AAIT) which reports directly to the Appointing Authority. The AAIT operates under the procedural direction of DDAAFS. In the event of an accident involving a civil registered ADF operated aircraft investigated by the Australian Transport Safety Bureau (ATSB) the provisions of the ATSB/ADF Accident Investigation Memorandum of Understanding will apply.

This AAIT report was produced by the DDAAFS for the Appointing Authority. This report remains the property of the Appointing Authority and may not be released to any agency unless specifically identified on the distribution list, or used for any purpose, without obtaining prior approval from the Appointing Authority.

Defence aircraft accident or incident safety investigations will be conducted in accordance with the provisions of Annex 13 to the ICAO Convention on International Civil Aviation, unless there is compelling military reasons the recommended standards and practices need to be changed.

The investigations are conducted for the sole purpose of determining aviation safety issues arising out of any accident or incident and will not pre-empt or replace any other necessary or requisite investigation by either Party. This is a 'Safety Investigation' and it is not the function of the DDAAFS to assign fault or blame nor determine civil, military or criminal liability.

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References:

A. ABR 5419 Volume 1, Revision 2 – Ship Helicopter Operations Manual

B. DSTO Accident Investigation Report CR-2007-0065 dated 12 Feb 07

INTRODUCTION

1. On 29 Nov 06, at approximately 1600M,[1] a detachment of four Black Hawk helicopters from 171 Avn Sqn, embarked in HMAS KANIMBLA during OP QUICKSTEP,[2] planned to fly a series of practice assault missions to the aft deck of the ship. The first element of the formation, two Black Hawks callsign GOLD ONE and TWO carried out the first serial of the planned mission without incident. The remaining two Black Hawks, callsign BLACK ONE and TWO, commenced their serial shortly thereafter. During BLACK ONE's initial attempt to conduct the serial the aircraft impacted the aft flight deck, resulting in catastrophic damage to the aircraft with the tailboom and tail rotor separating from the main fuselage. Immediately thereafter, the remaining fuselage section became airborne, rotating and transitioning laterally across the flight deck before subsequently falling into the ocean on the starboard side of the ship.

2. There were ten personnel aboard the aircraft, consisting of four crew and six special operations (SO) personnel. After the aircraft impacted the water, at least nine personnel egressed the aircraft, which had rapidly begun to sink. Of those on board, nine were successfully rescued by the ship's company; however, the aircraft captain of BLACK ONE surfaced in an unconscious state and was not able to be resuscitated. One SO member on board the accident aircraft was not located during the initial rescue. An extensive air and sea search was then conducted until 06 Dec 06,[3] without success. The member was declared missing and presumed dead four days after the accident.

3. On notification of the accident, an Aircraft Accident Investigation Team (AAIT) was formed by CJTF 636 (COMD 1 DIV, MAJGEN A. Power)[i] to investigate the circumstances of the accident in accordance with standing terms of reference as published in the Safety Manual Vol 3 – Aviation Safety Part 1 (Defence Aviation Safety Manual (DASM)). The team comprised the following members:[4]

a. Officer In Charge – 8183337 WGCDR Pierre F.J. Blais DDAS DDAAFS,

b. Senior Investigator – 8231067 MAJ Raymond J. Pearson AS8 DDAAFS,

c. Operations Member – 8135886 SQNLDR John P. Kowald AS1 DDAAFS,

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1. Timings throughout the report is local time of the occurrence location which was Greenwich Mean Time plus 12 hours.

2 OP QUICKSTEP was the codename for the ADF operations to ensure the safety and services protected evacuation of Australian nationals and approved foreign nationals in Fiji.

3 FRAGO 56 to JTF 636 OPORD 01/06 OP QUICKSTEP – Cessation of SAR, DTG 062022Z Dec 06.

4 The AAIT make-up was changed from the original message once the scope of the investigative effort was assessed. The final team make-up was as per the minute issued by COMD 1 DIV.

d. Maintenance/Engineer– 8153039 WOFF Ronald Dyball AS6A DDAAFS,

e. Aircrewman Loadmaster – 8266089 WO2 E. Balarezo AS10 DDAAFS,

f. Operations/Human Factors – 8072713 LCDR Richard Sellers HF DDAAFS,

g. Aviation Medicine - 8163669 SQNLDR Glenn Pascoe T/CO AVMED, and

h. Subject Matter Expert – 8240613 MAJ Scott Nicholls SOJ35A SO HQ.

4. Additional support to the team was provided by a number of external agencies including:

a. the Defence Science and Technology Organisation, coordinated through the Air Vehicles Division, Fisherman's Bend, Melbourne;

b. CAE Inc.; and

c. Army Aviation Training Centre.

INVESTIGATION - GENERAL

5. The AAIT investigation was conducted in accordance with the mandate of DDAAFS. The AAIT report is structured to provide factual information to determine the accident sequence and ascertain those factors (hazards) which directly and/or indirectly led to the accident. Where factual information was not available some analysis is provided to establish the most probable sequence of events and associated contributory factors. During the course of the investigation, the AAIT also investigated some aspects of aircrew and passenger survivability and analysed some aspects of the effectiveness of the emergency response. The AAIT did not investigate the search and rescue operation for Trooper (TPR) Porter, as this was beyond the scope of the team's mandate. However, some data was collected that may be relevant to an inquiry into the operation.

6. The AAIT commenced interviews with personnel during the sea transit to HMAS KANIMBLA whilst on HMAS NEWCASTLE. An element of the AAIT conducted interviews in Townsville over the period 01-02 Dec 06 after the repatriation of survivors. Interviews of witnesses on HMAS KANIMBLA commenced on arrival on 02 Dec 06 and continued over a two day period. A number of contemporaneous statements were collected, reviewed and analysed to help provide data and information relating to areas of interest for the establishment of the sequence of events and to identify immediate safety concerns. On 05 Dec 06, the AAIT was transferred to HMAS SUCCESS for a three-day transit to Auckland before returning to Australia by commercial flights on 08 Dec 06. During the transit, the time was used to review statements, view close circuit TV (CCTV) video and plan for follow-on tasks in Australia before the reduced activity period over Christmas. The OIC AAIT proceeded directly to DSTO in Melbourne to deliver a video tape that had been taken by one of the passenger survivors using a hand-held video camera. The tape had been contaminated by sea water for some time following the accident and required careful handling to extract video images. The information provided by the video recording is referred to in the report and was used to help establish the sequence of events.

7. At the time of writing of this report, the decision to survey, and if possible recover the wreckage, had been recommended by MINDEF.[iii] Noting that there may be a possibility to recover the flight data recorder and the cockpit voice recorder that may reveal more information follow-on analysis and reporting would be required should this eventuate.

8. During the course of the investigation, safety recommendations and concerns relating to survivability and safety equipment worn by the survivors were passed to the Appointing Authority for further consideration. These are detailed in the report at the appropriate section and notes are added to indicate the actions to date that have been taken to address the issue.

9. The body of the report makes use of footnotes to expand on information provided and endnotes to identify the reference material used and registered by the AAIT as the source of factual information. Note that the ship's CCTV displayed timings were not synchronised with the local time of day, however, they were synchronised between each other. In referencing video imagery every attempt is made to provide both the local time and the CCTV time in endnotes. Every attempt has been made to structure the report in accordance with international standards and the DASM.

10. A summary of acronyms and a glossary or terms used in this document are provided at annexes A and B respectively. A list of witnesses interviewed by the AAIT is at annex C. A list of the reference data registered by the AAIT is at annex D.

FACTUAL INFORMATION

Background

11. On 02 Nov 06 the Government of Australia approved the pre-positioning of ADF Force Elements (FE) in the vicinity of Fiji in order to provide rapid military response options to an emerging situation. The FE involved included HMAS KANIMBLA, a detachment from 171 Avn Sqn of four Black Hawks, and elements of SASR and 4 RAR personnel. The 171 Avn Sqn detachment included a total of 49 personnel, of which there were eight pilots and eight loadmasters, representing enough crew to man each of the four aircraft. The FE concentrated in Townsville and departed on 03 Nov 06 and arrived in the Fiji territorial waters on 07 Nov 06. Planning for the operations was conducted while underway. Over the period prior to the accident, flying training, both day and night, was being conducted to maintain currency in the various roles anticipated for the planned operation.

History of the flight

12. On the day of the accident, the four embarked Black Hawks were programmed to conduct assault training to the aft flight deck of the ship, simulating a static objective as the ship was not underway.[5] The planned mission required two elements of two aircraft each with allocated call-signs of BLACK and GOLD. The practice assaults were planned to terminate in an out of ground effect (OGE) hover over the aft flight deck of HMAS KANIMBLA whilst simulating a roping insertion.

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5. Previous missions during the operation were flown with both HMAS NEWCASTLE and KANIMBLA underway.

13. The accident aircraft captain, who was also a QFI,[iv] planned and ~~subsequently~~ briefed the sorties on the morning of the accident. The sorties, assessed as high risk in accordance with ADF aviation risk management (AVRM) procedure, were authorised by the detachment commander who attended the orders and signed the authorisation ~~sheets~~ (form OA82).[v]

14. The first element of GOLD ONE and TWO departed HMAS KANIMBLA at 1502 and 1525 hours respectively, followed by BLACK ONE and TWO at 1556 and 1602 hours respectively.[vi] This time interval and sequence was required in order to provide a clear flight deck for the movement of BLACK ONE and TWO from the ship's hangar (the aft flight deck of HMAS KANIMBLA is only capable of handling two Black Hawks at a time). GOLD ONE and TWO loitered in the vicinity of HMAS KANIMBLA whilst awaiting the departure of BLACK ONE and TWO.

15. Once BLACK ONE and TWO had departed from HMAS KANIMBLA, GOLD ONE and TWO commenced their run-in from the initial point (IP) which was located 10 km off the bow of the ship, in a stream formation. In this first approach, the leader of the GOLD element elected to use the starboard side of the ship as the *active* side[6], which was planned to approach from the ship's bow followed by a **right turn** in order to approach the aft flight deck in a hover in preparation for the assault. Once GOLD ONE and TWO had completed their approaches and simulated assault, BLACK ONE and TWO commenced their run-ins, similarly in a stream formation. On this occasion the captain of BLACK ONE elected to use the port side of the ship as the *active* side, as he was seated on this side and wished to conduct the first practise. This was planned to be a similar approach to that of GOLD ONE and TWO, except that the formation would instead pass along the port side of the ship followed by a **left turn** through 90^0 into the assault position.

16. At approximately 1607 hours, BLACK ONE commenced its run-in from the IP. Figure 1 is an image captured from the final usable frame of a hand held video camera during the approach and moments before the ship's forward looking camera recorded the aircraft approach the ship from ahead and then pass along the port side at 16:10 hours[vii] (figure 2). [viii]

6 If required, control of the aircraft is handed to the pilot who is seated on the active side so that the objective is clearly visible.

Figure 1. Image captured from in-flight digital hand-held camera

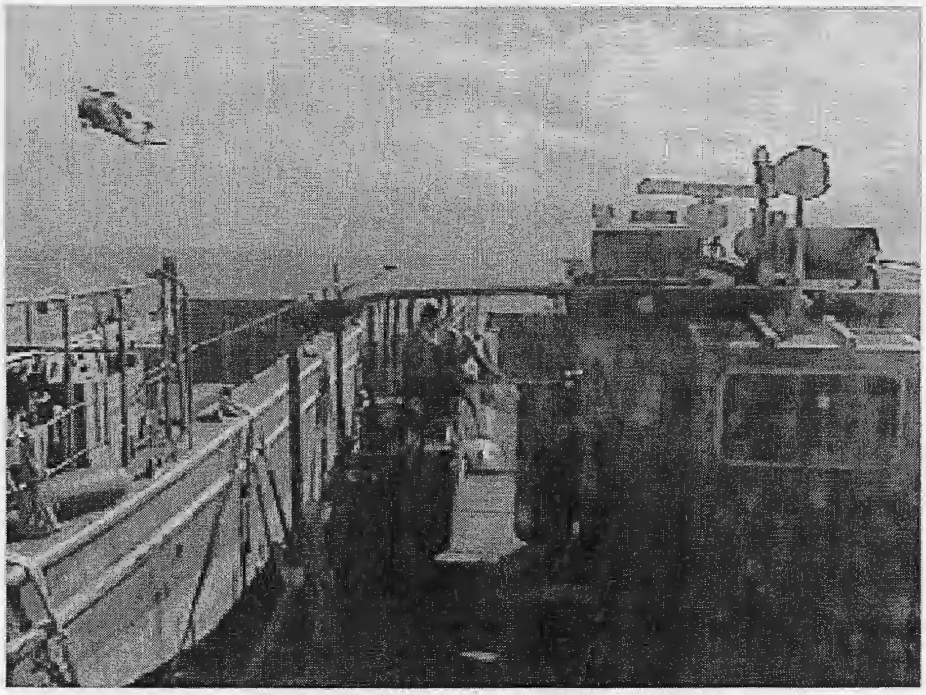


Figure 2. Image captured from the forward looking flight deck camera

17. The aircraft was similarly observed by eye witnesses to approach the ship from ahead, commence a decelerative flare, pass along the port side of the ship, and turn left toward the flight aft deck. The aircraft, at the completion of the left turn, and as recorded by the ship's aft looking camera, proceeded to descend toward the aft flight deck, impacting the deck mid-way between number two and three landing spots.ix Figure 3 is an image captured from the aft looking CCTV as the aircraft enters the field of view over the aft flight deck. Figure 4 is a diagram of the flight track with respect to the ship.

Figure 3. Image captured from the aft flight deck camera[7]

7 Note time is represented in GMT and approx 12 minutes ahead of the correct time.

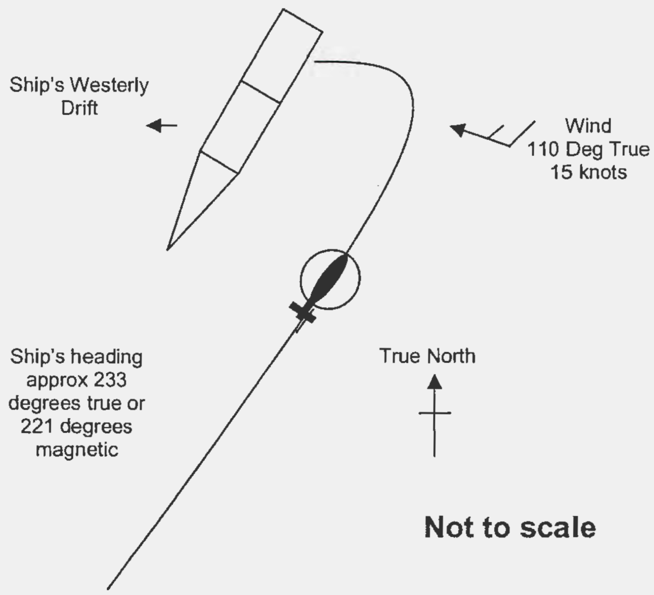


Figure 4. BLACK ONE's flight profile

18. During the accident sequence, the fuselage impacted the flight deck, whilst the tail boom and rotor separated from the aircraft after colliding with the edge of the flight deck, falling over the port side of the ship. The remaining fuselage section became airborne, rotating and transitioning laterally across the flight deck, eventually falling into the ocean on the starboard side of the ship.

19. The following images depict the aircraft post accident on deck and subsequent manoeuvre across the deck.

Aircraft lifts off flight deck – tail separates

Rotation begins after getting airborne

Rotation continues – left side pilot door open

Aircraft transitions across flight deck

Rotation continues

Tail section falls to port side – aircraft continues over starboard side

Figure 5. Captured images of accident sequence

20. The accident was noted in the ship's officer of the watch (OOW) log at time 1611 hours, and a GPS fix was taken at 1614 hours at latitude 18^0 44.89' South, longitude 176^0 56.40' East.[x] There are some discrepancies with respect to the exact location of the ship at the time as described in para 78, **Ship's drift.**

Concurrent activities

21. During the conduct of the flying operations, diving activities involving SO divers and one of the ship's rigid hull inflatable boats (RHIB) was being conducted around the ship. At the time of the accident the RHIB and divers were being recovered onto the port side of the ship. This coincident diving activity was fortuitous in that the RHIB, divers and personnel trained in cardiac pulmonary resuscitation (CPR), were able to provide immediate assistance to the survivors.

Personnel involved

22. Table 1 details the personnel on board BLACK ONE. The crew were listed in form OA82 – Authorisation Book,[xi] and the passengers were listed on the sniper sortie training programme.[xii]

Rank/Name	**DOB**	**PMKEYS**	**Position**	**Unit**
CAPT Bingley	29-Jan-71	8223861	Aircraft Captain	171 Avn Sqn
CAPT Grisinger	15-Feb-83	8221043	Co-pilot	171 Avn Sqn
WO2Rogers	02-Aug-64	8215502	Right side Loadmaster	171 Avn Sqn
CPL Irwin	17-Nov-73	8266468	Left side Loadmaster	171 Avn Sqn
TPR Porter	29-Dec-77	8240331	Pax L forward door opening	SASR
TPR Wilson	28-Nov-75	8248890	Pax R forward door opening	SASR
CPL Maylor	29-Apr-67	8238820	Pax aircraft centre	SASR
TPR Oliver	08-Oct-73	8245514	Pax L aft door opening	SASR
TPR Irvine	08-Sep-80	8239942	Pax R aft door opening	SASR
TPR Shephard	11-Dec-80	8114983	Pax L rear seat	SASR

Table 1. List of crew and passengers in BLACK ONE

23. The seating arrangements in the aircraft at the time of the accident are depicted in figure 6.

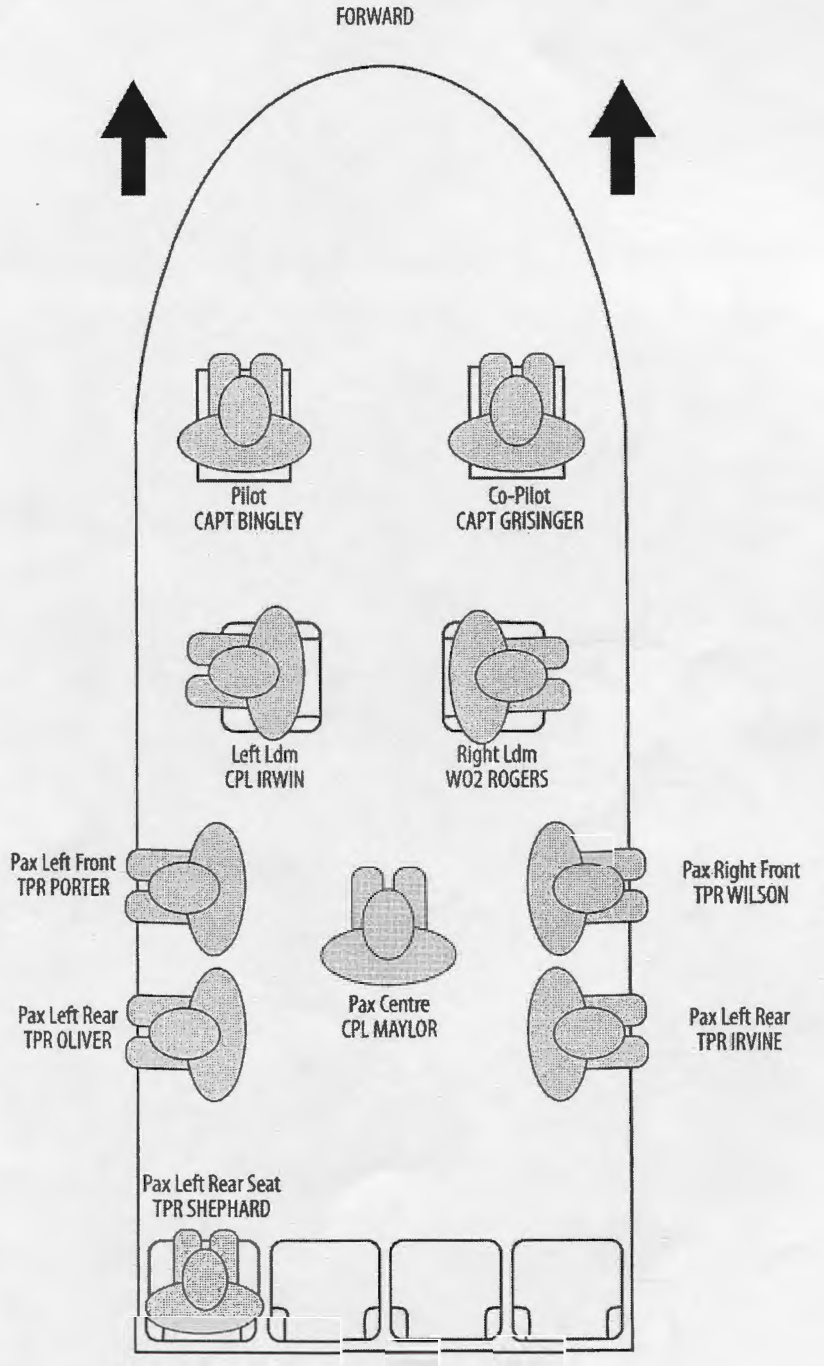


Figure 6. Crew and passenger positions in BLACK ONE at the time of the accident

Injuries to personnel

24. Table 2 details the injuries sustained by crew and passengers of BLACK ONE.

Position	Name	Injuries and status
L Pilot station	CAPT Bingley	Drowned; Abrasions to nose, chin, L knee, R leg. Bilateral haemorrhage in middle ears. Internal haemorrhage around larynx
R Pilot station	CAPT Grisinger	Bruise L elbow, tongue bite, walking
L Ldm	CPL Irwin	Soft tissue injury (STI) R buttock, abrasion R flank, bruise behind L knee, walking
R Ldm	WO2 Rogers	STI thoracolumbar spine, L scapula, R knee, L wrist, L ankle, sitting/litter
Pax L front	TPR Porter	Missing, presumed dead
Pax R front	TPR Wilson	STI lumbar spine and buttocks, walking
Pax centre	CPL Maylor	Facial cut, bruising, minor head injury, sea water aspiration, walking
Pax L rear	TPR Oliver	T12/L1 crush fracture 50%, litter
Pax R rear	TPR Irvine	Sacro-coccygeal injury, suspect L rib fracture
Pax L rear seat	TPR Shephard	STI back, litter

Table 2. Injuries sustained by crew and passengers of BLACK ONE

Medical reviews

25. No recent medical history of relevance was apparent for aircrew. The medical-in-confidence report is referenced at annex E[8].

26. **Post accident toxicology.** Blood samples for post accident toxicology were taken from each of the surviving aircrew and SAS troops at the primary casualty reception facility (PCRF) aboard HMAS KANIMBLA on 29 Nov 06, some 5-6 hours post accident. These samples were submitted on 04 Dec 06 to 3 Combat Support Hospital, RAAF Base Richmond for processing in accordance with ADFP 731 Medical Guide to Aircraft Accidents/Incidents Investigation. There were no traces of alcohol, non-prescribed or illicit drugs detected in any of the samples. Due to the timing of the sample collection, most samples returned positive

8 Medical-in-confidence reports, post military aviation accidents are held by AVMED and are not read by other AAIT members. Release to other agencies or inquiries is subject to strict medical confidentiality protocols.

results for medications prescribed in the immediate medical management of their injuries. Toxicology samples for the deceased pilot were collected during the autopsy on 04 Dec 06. There were no traces of alcohol or illicit drugs detected. The results are incorporated into annex E.

Life support equipment

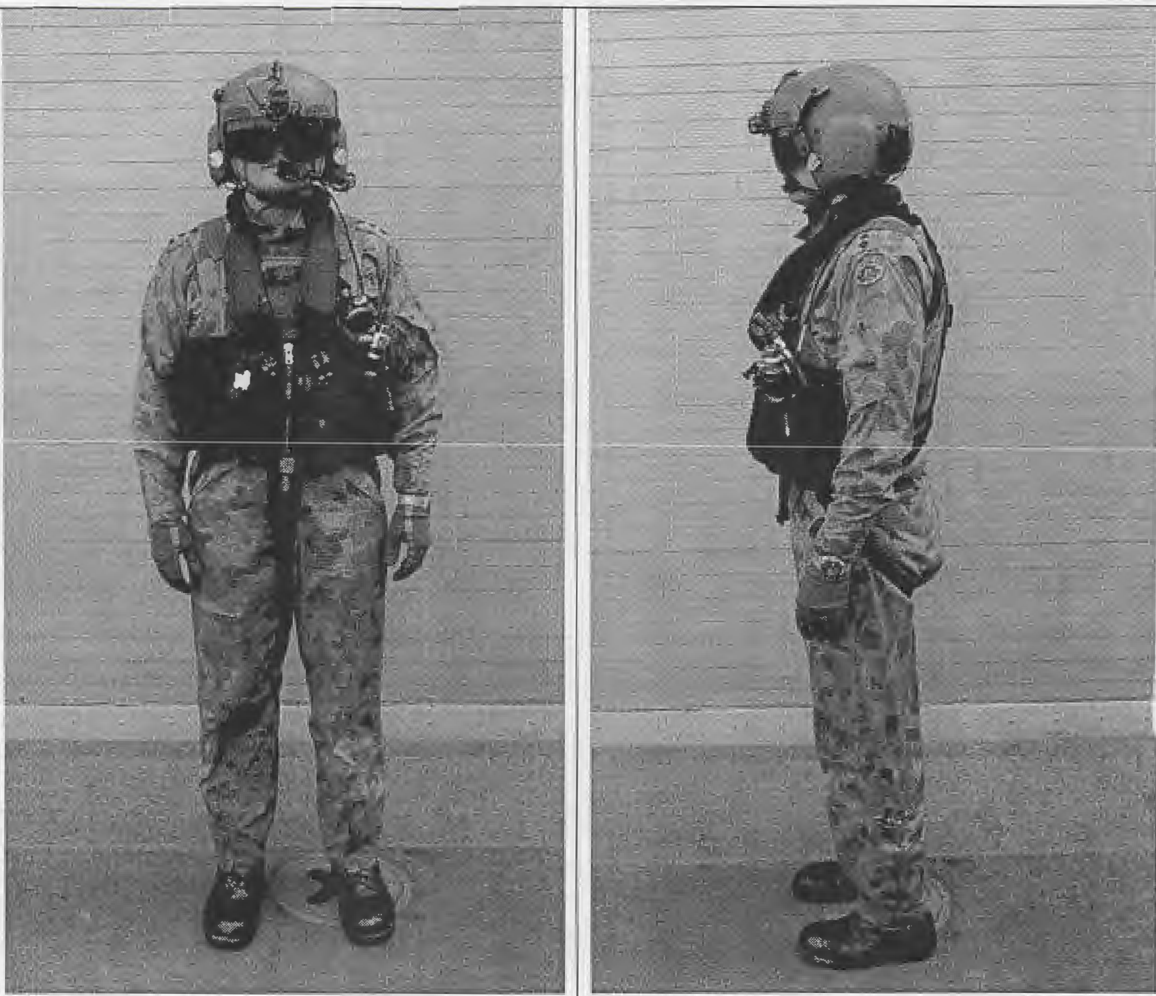
27. **Aircrew.** The following personal life support equipment (LSE) was retrieved from both the aircrew and the water after the accident:

a. **Pilot**. HGU–56P aircrew helmet damaged, Simula Low Profile Survival Vest (LPSV) with LPU–34/P flotation collar incomplete with missing right pocket and both bladders activated, no HABD bottle or regulator, ballistic vest rear panel only. Full set of flying clothing.

b. **Co-pilot**. HGU–56P aircrew helmet damaged, Simula Low Profile Survival Vest (LPSV) with LPU–34/P flotation collar complete with single bladder activated, HABD bottle used, full set flying clothing, ballistic vest complete.

c. **Left side loadmaster**. HGU–56P aircrew helmet slight damage, SALA International SO28 Loadmaster Harness with Secumar flotation collar activated, HABD bottle used, no HABD bottle strap, regulator mouthpiece twisted, ballistic vest complete, Ephese Aircrew Breathing System (ABS), full set flying clothing.

d. **Right side loadmaster**. HGU–56P aircrew helmet slight damage, SALA International SO28 Loadmaster Harness with Secumar flotation collar activated, HABD bottle unused, HABD bottle strap present, regulator mouthpiece partially separated, ballistic vest complete, Ephese Aircrew Breathing System (ABS), full set flying clothing.



Pilot – Front view | Pilot – Side view

Figure 7. Pilot LSE

Loadmaster - Side view

Loadmaster – Front view

Figure 8. Loadmaster LSE

28. **SO personnel.** The SO personnel were equipped with the following LSE:

a. Kevlar helmet. Helmet ground troops ECH NSN 8470-66-151-7621. One member did not wear a helmet IAW the waiver to operate as airborne safety operator.[xiii] All helmets were retained by SO personnel on HMAS KANIMBLA.

b. Personal flotation device. RFD-60C NSN 4220-66-150-8335. All five had been activated.

c. Breathing apparatus self contained alternate air supply commonly known as emergency breathing air (EBA). NSN 66-143-2305. Four EBA bottles, all turned off with the gauge reading 2000lb pressure (full capacity) were recovered. The only member who used his EBA bottle was TPR Shephard (a qualified diver) and his bottle was not recovered.

d. Helicopter Restraint Strop (HRS). The HRS is a one inch green tubular tape with quick release devices fitted to both ends used to restrain troops inside helicopters for operational contingency loading tasks.[xiv] All HRS were retained by SO personnel on HMAS KANIMBLA.

Passenger – Front view

Passenger – Side view

Figure 9. Passenger LSE

29. Further analysis of the LSE is to be performed by AESSO ALSE and AVMED at RAAF Base Edinburgh. This will be provided as a separate report to the Appointing Authority.

Egress and survival

30. After the aircraft impacted the water and sank on the starboard side of the ship, four personnel were observed to surface almost immediately on the starboard side. A fifth person was observed by witnesses beneath the water's surface on ascent. Eventually seven personnel were seen on the starboard side. Soon after this, another survivor was seen on the port side of the ship. Some time later an aircrew helmet and what appeared to be an empty life vest

surfaced on the port side (CAPT Bingley). As the ship was drifting to the west (starboard side) it was surmised that the longer it took to egress the aircraft, the more likely it was that the ship drifted over the ditched aircraft and hence the appearance of personnel on the port side. It is unclear exactly how long after the aircraft sank that the survivor appeared on the port side, however, from statements from survivors, witnesses, and rescuers, the likely depth and order of egress, and surfacing is as shown in Table 3.[xv]

Rank/Name	**Crew Position**	**Estimated Egress Order**	**Estimated Depth of Egress**	**Side Surfaced**
TPR Irvine	Pax R rear	1st or 2nd	3m	Starboard
CAPT Grisinger	R Pilot station	2nd or 3rd	<5m	Starboard
TPR Wilson	Pax R front	3rd or 4th	<5m	Starboard
WO2 Rogers	R Ldm	3rd or 4th	6m	Starboard
CPL Maylor	Pax middle	5th	10m	Starboard
CPL Irwin	L Ldm	6th or 7th	20-30m	Starboard
TPR Oliver	Pax L rear	6th or 7th	20-30m	Starboard
TPR Shephard	Pax L rear seat	8th	20-30m	Under ship then Port
CAPT Bingley	L Pilot station	9th	>30 m	Port

Table 3. Likely depth, order of egress and surfacing of crew and passengers

31. The egress and survival issues listed in table 4 were identified through statements and preliminary examination of the LSE.

Rank/Name	Crew Position	Egress/ Survival Problems	HABD used
CAPT Bingley	L Pilot station	Helmet damage and separation from member prior to surfacing, HABD bottle and regulator missing. Member unconscious, head below water line at surface despite both bladders of LPSV being inflated. HABD mouthpiece remained in mouth but separated from regulator (missing).	Unknown
CAPT Grisinger	R Pilot station	Member unable to locate LPSV inflation handle until on the surface. Only inflated one side as enough flotation gained.	Yes
CPL Irwin	L Ldm	ABS Blower caught on door gun, not enough flotation from Secumar, member had to remove helmet and use as additional flotation device.	Yes
WO2 Rogers	R Ldm	ABS Blower hindered seatbelt release.	No
TPR Porter	Pax L Front	Unknown	Unknown
TPR Wilson	Pax R front	Obstructed exit pathway cleared spontaneously.	No
CPL Maylor	Pax middle	No helmet, member knocked out or dazed and 'came to' underwater, inhaled water during ascent.	No
TPR Oliver	Pax L rear	Strop at full extension, unclipped at belt, member's egress delayed by aircraft comms lead, requiring removal of helmet and headset.	No
TPR Irvine	Pax R rear	AD strap obstructed member's egress.	No
TPR Shephard	Pax L rear seat	L foot stuck under seat, member ran out of EBA air during ascent.	Yes

Table 4. Egress and survival issues

Survival equipment issues

32. **Aircrew safety survival equipment ensemble.** The Aircrew Safety Survival Equipment Ensemble (ASSEE) worn by 171 Avn Sqn was acquired and approved for use

during OP GOLD[9] in 2000 and was to be withdrawn from service after OP GOLD. The Gentex HGU 56P helmet and the communication ear piece (CEP) are the only components of the ASSEE that have achieved Service Release (SR) for use on Black Hawk and Chinook. Army Operational Airworthiness Authority Clearance (OOAC) is provided for the remainder of the ASSEE in SFI 12/2003 - *Use of the Aircrew Safety Survival Equipment Ensemble.*[xvi] The ASSEE comprises:

a. Gentex HGU–56P aircrew helmet and CEP,

b. Ephese Aircrew Breathing System (ABS) and safety chin strap,

c. Simula Low Profile Survival Vest (LPSV) with LPU–34/P flotation collar for pilots,

d. SALA International SO28 Loadmaster Harness with Secumar flotation collar for Loadmasters,

e. Combat Clothing Australia (CCA) Ballistic Vest, and

f. Helicopter Aircrew Breathing Device (HABD) (previously referred to generically as HEEDS).

33. **Security of mouth piece to regulator and HABD bottle.** A number of safety recommendations were made during the preliminary field investigations as reported via SITREP[xvii] to the appointing authority. These recommendations related to the adequacy of aircrew and passenger life support equipment. Specifically, the security of the mouth piece to the HABD regulator (figure 7 refers) and the HABD bottle to the aircrew survival vest prompted the Army Aviation Support Project Office (AASPO) to issue two special technical investigations (STI) 379 and 380 to address these issues for Army Aviation aircrew. The HABD bottle was secured to the life preserver with either a simple pocket and neck strap (pilot), or a fitted adjustable pocket without a neck strap (loadmaster). In either case it appears the bottle can be dislodged easily from the life preserver, potentially increasing snag risk and loss of the HABD during egress. The AAIT was made aware[xviii] of the of modification status to the loadmaster survival vest to address the security issue. The AAIT has been advised that the interim modification to the pilot LPSV requires further testing and evaluation.[xix]

9 OP GOLD was the codename of the operation for the ADF's support to the 2000 Olympics in Sydney.

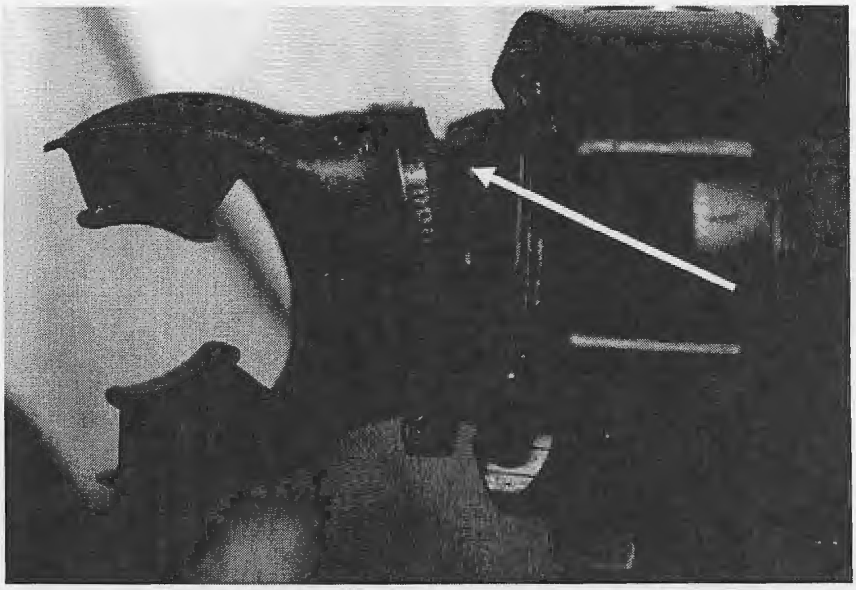


Figure 10. Mouth piece dislodged from regulator

34. **SASR EBA equipment**. The AAIT also noted a deficiency in the regulator used by the SASR passengers. It was noted that of the survivors who surfaced in the first few seconds after the accident, none had used their EBA. Upon inspection of the bottles, all were selected to the 'OFF' position. The AAIT was advised that during flight operations, the airflow near the doors and within the Black Hawk cabin affects the regulator to the extent that air is inadvertently released from the bottle resulting in depleted bottles by the end of the sortie. The regulator deficiency was recognised by the deployed personnel and therefore instigated a mitigation strategy of keeping the bottle 'OFF' in-flight so that it would be full should it be required. Fortunately, the last passenger survivor to surface had diving experience and, turned his bottle to the 'ON' position during his egress sequence. However, due to the depth from which he egressed he ran out of air relatively quickly. His bottle was discarded during the final ascent. Loadmaster HABD regulators have a mouth piece guard protecting the system from inadvertent bottle depletion. A report on defective or unsuitable materiel (RODUM) was generated by the CO SASR upon return to Australia to address the regulator problem.

35. **Flotation devices**. The AAIT reported on the suitability of the flotation devices used by aircrew wearing body armour in the SITREP on 02 Dec 06. Further investigation revealed that the aircrew ensemble had been trialled and proved to be adequate if worn correctly. It would seem that some aircrew keep their leg straps loose for comfort during flight. This unfortunately allows the LPSV to rise above the user's shoulders making it difficult to swim and potentially not keeping a person's head above water if unconscious. All those who survived, indicated that inflation of their life preserver was initiated outside the aircraft. It is acknowledged that inflation of the life preserver whilst still inside the aircraft could hinder egress. The following are other specific issues:

a. **Passenger and loadmaster life preservers**. Some of the passengers indicated their life preservers did not provide enough buoyancy particularly at depth. The LHS loadmaster removed his helmet in order to provide additional buoyancy on the surface.

b. **Pilot's life preserver.** The co-pilot was unable to initiate inflation of his LPSV until on the water's surface. The LPSV has two buoyancy chambers which operate independently via two inflation toggles. These are of a "handle" style, however, the handle is stitched at the centre, making inadvertent and intentional operation more difficult. Of more concern was the functioning of CAPT Bingley's LPSV. Although both chambers were correctly inflated, once on the surface the LPSV failed to keep the member's head above the water line. Photo evidence suggests the leg straps were in place, although loosely applied, thus allowing the LPSV to ride up above CAPT Bingley's head.[xx] Interviews with 171 Avn Sqn aircrew and life support fitters indicate some crew may have been in the habit of loosening the leg straps to improve comfort in flight.

36. Prior to departing HMAS KANIMBLA, the AAIT briefed all aircrew on the need to properly wear life support equipment. The AAIT has been informed that SOHQ has initiated an investigation into the adequacy of flotation devices for combat ensembles.[xxi]

Finding. There were deficiencies in some of the personal LSE and role equipment worn by aircrew and the SO personnel on the flight.

37. **HUET**. Helicopter Underwater Escape Training (HUET) is conducted in order to improve the awareness and techniques involved in helicopter egress and escape. The common problem with helicopter egress is disorientation and inability to find an exit. Part of the training relies on a fixed point of reference, such as the seat you are strapped into. As five of the passengers were using the HRS (see para 39) and not in seats, they were more likely to become disorientated than the crew. The AAIT noted that TPR Irvine had not completed any HUET[xxii] as required by Army Training Instruction 7-3 version 1.1 dated 03 Sep 04.

38. **EBA training**. It was also noted that, although the EBA forms part of the SO personnel LSE ensemble, the equipment is not used by all personnel during underwater training. However, theoretical training in use of the EBA is provided, and where personnel are qualified as a diver and medically-in-date, they are permitted to use it underwater.

Finding. Not all SO personnel had completed HUET.

Finding. Underwater EBA training is not conducted for personnel other than qualified divers.

39. **The HRS**. The HRS, although used by SO personnel, has not been through the formal approval process. The latest documentation, dated 14 Jul 06, examined by the AAIT indicates that design acceptance is being sought.[xxiii] The HRS configuration for the passengers had two quick-release mechanisms to enable egress. The AAIT arranged a mock-up of the cabin layout and troop disposition of BLACK ONE whilst on-board HMAS KANIMBLA (figure 11), in order to gain an understanding of the passenger loading configuration and the use of the HRS (figure 12).

Figure 11. Mock-up for passenger loading, cabin view looking aft

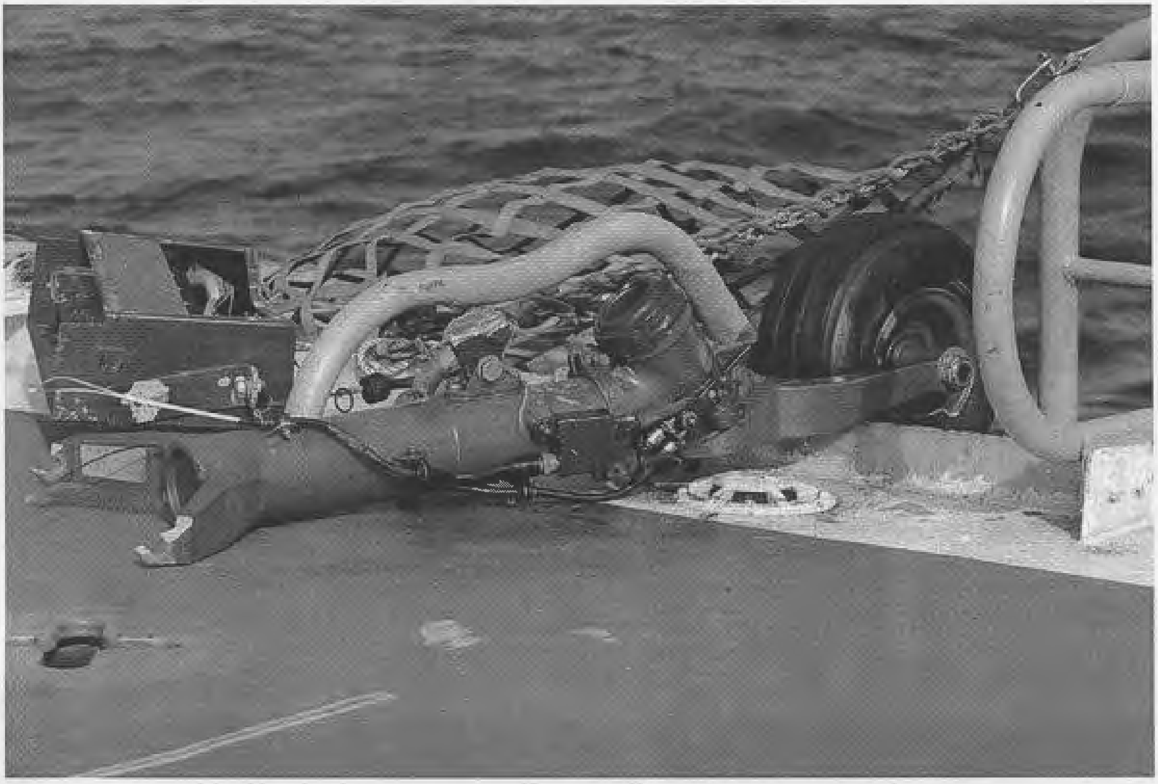
Figure 12. Example of HRS anchor points

Damage to the aircraft

40. As assessed from the CCTV footage the aircraft appeared to sustain catastrophic damage to the fuselage and tail section. It is estimated that the aircraft is lying on the sea bed, approximately 3000 metres below the surface. At the time of writing of this report, the decision to survey, and if possible recover the wreckage, had been approved by MINDEF.[xxv]

Aircraft wreckage

41. Some aircraft wreckage was recovered from the surface of the ocean, the ship's sponsons and the aft flight deck. The largest component recovered was the tail wheel and strut as depicted in figure 10. Other components included shattered fibreglass pieces and splinters. Examination of these components did not reveal any pre-existing failures that may have contributed to the accident.



Figures 13. Tail wheel

Collateral damage

42. HMAS KANIMBLA sustained minor damage (figure 11), consisting of tyre rub, scrapes and gouges to the flight deck, along with damage to the port side flight deck ladder and sponson.

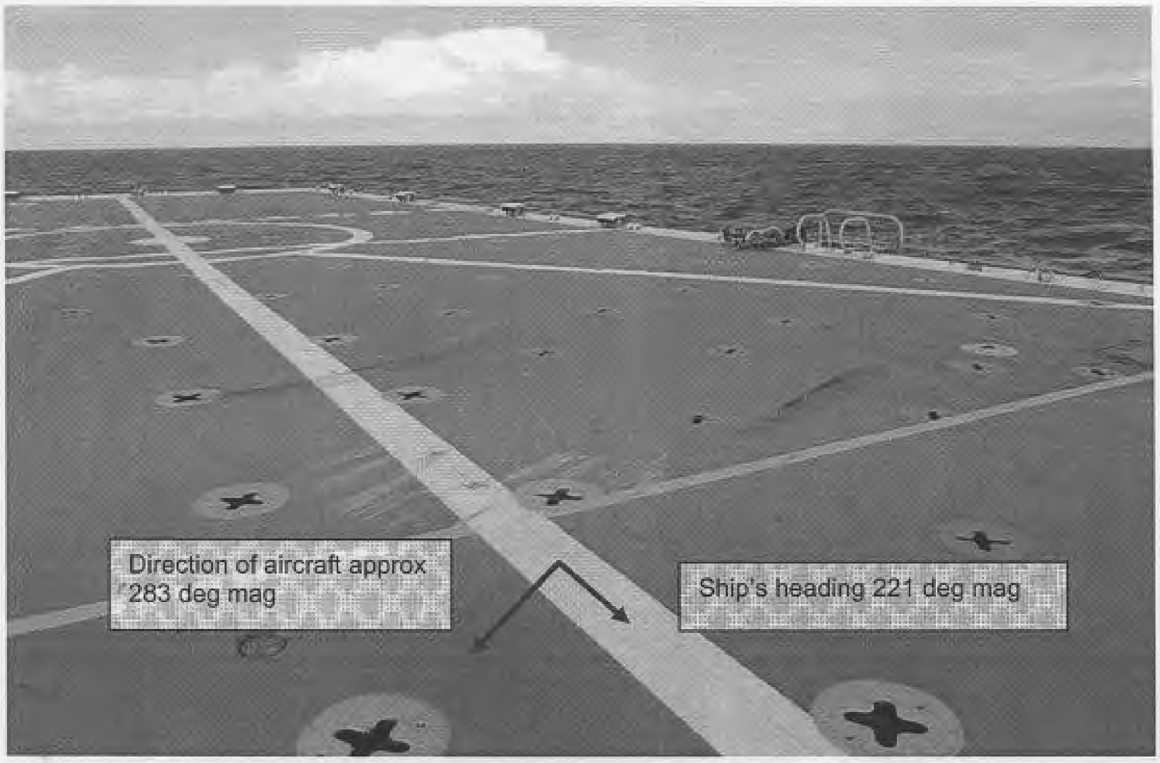


Figure 14. Impact marks on flight deck

43. Witness marks on the aft flight deck and analysis of the ship's closed circuit television (CCTV) indicated that the aircraft impacted in approximately 12 degrees left bank, with a nose down pitch of approximately 20 degrees. At the time of impact, the angle of the aircraft flight path to the ship's heading was noted as 62 degrees. This correlated to an aircraft magnetic heading of 283 degrees.

Environmental damage

44. Environmental damage consisted of jet fuel and aircraft lubricants being dispersed in the ocean from the aircraft. A slight slick was evident around the ship for a short period before being dispersed.

Aircrew currency and recency

CAPT Mark A. Bingley[xxvi]

45. CAPT Mark Bingley joined the Australian Army in Mar 90 and after initial recruit training, was allocated to the Royal Australian Infantry Corps. He transferred to the AAAvn Corps in Sep 97 and was awarded the Army Flying Badge after completing the Regimental Officer Basic Course in Jul 99, qualifying as a Category D pilot on the Black Hawk. He was then posted to 5 Avn Regt as a Black Hawk line pilot in Apr 00 and was awarded Category C on the Black Hawk in Oct 00. CAPT Bingley was selected to undertake instructor pilot training in the United States in 2002. He returned to Australia on posting to Army Aviation Training Centre (AAvnTC) 2004, and was awarded a qualification as a Category C Black

Hawk instructor rating in Jun 04. He remained at the AAvnTC as an instructor until posting to 171 Avn Sqn in Jan 05. At the time of the accident, he had accumulated a total of 2518.4 hours on all types, with 1489.3 as pilot-in-command. He had flown a total of 1887.6 hours on the Black Hawk of which 1115.8 hours was as pilot-in-command.

46. CAPT Bingley deployed with the aviation detachment embarked in HMAS KANIMBLA on 03 Nov 06. During the period 03–28 Nov 06, he conducted 28 sorties that totalled 27.8 flying hours (15.6 day and 12.2 at night on NVG) as aircraft captain. During the deployment he conducted the following sorties as aircraft captain:

a. Deck landing practice (DLP) to HMAS KANIMBLA and HMAS NEWCASTLE by day and night.

b. Ship underway recovery assaults.

c. Airborne support by fire (ASBF) practices.[10]

d. Airborne formation rejoin practices and general tasking.

47. During the period, it was estimated that CAPT Bingley conducted approximately 15-25 assaults as the flying pilot, with and without troops, to HMAS KANIMBLA. The approaches may have included ASBF and fast-rope serials to a ship underway travelling at approximately 10-15 knots. (Actual ASBF and fast-rope serials are not normally recorded and therefore only an estimate is provided.)

48. In the seven days prior to the accident CAPT Bingley had conducted 5.8 hrs flying (3.9 Day and 1.8 night) All tasking involved SO techniques to a ship underway, which would have been approximately 7-10 assaults. CAPT Bingley had not conducted any assaults to a static objective in the period.

49. CAPT Bingley was within allowable aircrew flight time limits at the time of the accident. The AAIT assessed that the number of hours and sorties flown is consistent with that required to maintain skills to perform as an aircraft captain in conducting SO profiles to a ship underway.

10 ASBF is sniper fire from the helicopter.

CAPT John C. Grisinger[xxvii]

50. CAPT John C. Grisinger joined the Australian Army in Jul 01 and commenced military flying training in Aug 03. He completed the Regimental Officer Basic Course in Jun 05, qualifying as a Category D pilot on the Black Hawk. He was then posted to 5 Avn Regt as a Black Hawk line pilot in Jun 05 followed by a posting to 171 Avn Sqn in Mar 06. He was awarded Category C on the Black Hawk in Mar 06. At the time of the accident he had accumulated a total of 626.9 hours on all types, with 32.8 as pilot-in-command. He had flown a total of 353.7 hours on the Black Hawk of which 9.5 hours was as pilot-in-command.

51. Capt Grisinger deployed with the aviation detachment embarked in HMAS KANIMBLA on 03 Nov 06. During the period 03-28 Nov 06, he conducted 13 sorties that totalled 14.5 flying hours (10.0 day and 4.5 night on NVG) as aircraft co-pilot. During the deployment he conducted the following sorties as aircraft co-pilot:

a. DLP to HMAS KANIMBLA and HMAS NEWCASTLE by day and night.

b. Ship underway recovery assaults.

c. ASBF.

d. Airborne formation rejoin practices and general tasking.

52. During the period CAPT Grisinger most likely conducted minimal SO approaches as a flying pilot but acted as a co-pilot during SO approaches to a ship underway. The approaches included ASBF and fast rope serials to a ship underway travelling between 10-15 knots.

53. In the seven days prior to the event CAPT Grisinger had conducted 3.9 hours flying, all by day. All tasking involved SO techniques to a ship underway. CAPT Grisinger most likely conducted 1-2 assaults to a ship underway as the flying pilot and acted as a co-pilot for the remainder. CAPT Grisinger had not conducted any assaults to a static objective during the period.

54. CAPT Grisinger was within allowable aircrew flight time limits at the time of the accident. The AAIT assessed that the amount of flying that he had undertaken is consistent with that required to maintain his proficiency as a co-pilot in conducting SO profiles to a ship underway.

WO2 Chris Rodgers[xxviii]

55. WO2 Chris D. Rodgers joined the Australian Army in Jul 86 and after initial recruit training was allocated to AAAvn Corps. He spent four years as a ground crewman before completing loadmaster training in Jun 91. He was then posted to 5 Avn Regt as a Category D loadmaster on Black Hawk and was upgraded to Category C loadmaster in Nov 93. WO2 Rodgers was selected to undertake loadmaster instructor training and qualified as a category C Black Hawk loadmaster instructor in Aug 96. He was posted to 171 Avn Sqn in Jan 05. At the time of the accident he had accumulated a total of 3785.1 hours on all types, of which

3713.1 hours are on the Black Hawk. At the time of the accident WO2 Rodgers had 1020.0 instructor hours on the Black Hawk.

56. WO2 Rodgers deployed with the aviation detachment embarked in HMAS KANIMBLA on 03 Nov 06. During the period 03-28 Nov 06 as an aircrewman loadmaster, he conducted 16 sorties that totalled 20.8 flying hours (9.1 day and 11.7 night on NVG). During the deployment he conducted the following sorties:

a. DLP to HMAS KANIMBLA and HMAS NEWCASTLE by day and night.

b. Ship underway recovery assaults.

c. ASBF.

d. Airborne formation rejoin practices and general tasking.

57. During the period WO2 Rodgers most likely conducted 10-20 assaults as the senior aircrewman loadmaster during SO approaches to a ship underway. The approaches may have included ASBF and fast-rope serials to a ship underway travelling between 10-15 knots.

58. In the seven days prior to the event WO2 Rodgers had conducted 3.3 hours flying (1.5 day and 1.8 night). All tasking involved SO techniques to a ship underway. WO2 Rodgers had not conducted any assaults to a static objective in the period.

59. WO2 Rodgers was within allowable aircrew flight time limits at the time of the accident.

CPL Phil Irwin[xxix]

60. CPL P.G. Irwin joined the Australian Army in Jan 92 and after initial recruit training was allocated to the Royal Australian Artillery Corps. Upon completion of loadmaster training in Mar 04, CPL Irwin transferred to AAAvn and was posted to 5 Avn Regt as a Category D loadmaster on Black Hawk. He was posted to 171 Avn Sqn in Jan 05 and upgraded to Category C loadmaster in Dec 05. At the time of the accident he had accumulated a total of 694.2 hours on all types, of which 636.1 hours are on the Black Hawk.

61. CPL Irwin deployed with the aircraft embarked in HMAS KANIMBLA on 03 Nov 06. During the period 03-28 Nov 06 he conducted 17 sorties that totalled 20.9 hrs (9.1hrs day and 12.0 night on NVG) as aircrewman loadmaster. During the deployment he conducted the following sorties:

a. DLP to HMAS KANIMBLA and HMAS NEWCASTLE by day and night.

b. Ship underway recovery assaults.

c. ASBF.

d. Airborne formation rejoin practices and general tasking.

62. During the period CPL Irwin most likely conducted 10-20 assaults during SO approaches to a ship underway. The approaches may have included ASBF and fast-rope serials to a ship underway travelling between 10-15 knots.

63. In the seven days prior to the event CPL Irwin had conducted 3.3 hrs flying (1.5 day and 1.8 night). All tasking involved SO techniques to a ship underway. CPL Irwin had not conducted any assaults to a static objective in the period.

64. CPL Irwin was within allowable aircrew flight time limits at the time of the accident.

Aircrew training discrepancies

65. An audit of CAPT Grisinger's workbook revealed a deficiency in CRM training. The workbook reflected that a waiver was granted from HQ 16 Bde (Avn) until Sep 05. Due to no further evidence of a waiver in the workbook, assistance was requested from HQ 16 Bde (Avn) and 5 Avn Regt orderly room to search for any correspondence either granting CAPT Grisinger a CRM waiver or evidence that CAPT Grisinger had attended a CRM course. A further waiver was discovered granting him a waiver from Sep 05 to Nov 05, but no evidence was found that CAPT Grisinger had attended a CRM course. An email was written to CAPT Grisinger, who was deployed on OP QUICKSTEP at the time, requesting any information of a waiver or a CRM course report. He confirmed that he had not attended a CRM course, but he stated that he was put on a waiver for the next available course by HQ 16 Bde (Avn) in Nov 05. No evidence of this waiver was found. An email to the 171 Avn Sqn detachment commander on OP QUICKSTEP was sent to notify him of CAPT Grisinger's CRM deficiency and it was suggested that a short duration waiver be requested from HQ 16 Bde (Avn) to cover their current commitments.[xxx]

Finding. One aircrew member had not completed CRM training.

66. Apart from the CRM qualification, CAPT Grisinger's currency for fixed wing instrument landing systems and localizer (FWILSFFW) approaches had also lapsed on 21 Nov 06 (the currency for FWILSFFW was not possible nor considered relevant for the area of operations).

67. As confirmed on PMKeyS, and in the aircrew member summary status sheets, all remaining aircrew members were current and qualified to perform the tasks assigned.

Weather

68. The area forecast used by the crew during the pre-flight briefings indicated that the surface wind would be from 130^0 true at 7-12 knots, maximum temperature of 29^0 Celsius, visibility of 15-20 km, reducing to 10-15 km in light showers. The conditions indicated that the sky would be partly cloudy with isolated showers and thunderstorms in the afternoon and evening.[xxxi]

69. Photographs and video footage at the time of the accident indicates that the wind was from the aft port quarter of the ship at approximately 10-15 knots, with an estimated sea state of one to two.[xxxii]

HMAS KANIMBLA

70. **Characteristics**. The ship is fitted with a helicopter hangar capable of supporting up to four Army Black Hawk or three Sea King helicopters. Two helicopters can operate simultaneously from the aft flight deck, while a third helicopter can operate from the forward flight deck. Two Army LCM8 landing craft can be carried on the forward flight deck to provide ship-to-shore transport, although this capability is at the expense of forward flight deck operations. Dimensions of HMAS KANIMBLA are:

Length	159.2 m
Beam	21.2 m
Deck height	6.7 m
Masthead height	36 m

71. **Operations to ship not making way.** Flying regulations relevant to ship/helicopter operations are detailed in ABR 5419. Flight operations to a ship "at anchor/buoy or not making way" are described in Chapter 10 of ABR 5419. This instruction gives the following guidance for crews:

> *"10.1* ***SHOL****. Where a low motion SHOL has not been promulgated, the following factors regarding SHOL are to be applied to the conduct of helicopter operations at anchor/buoy or not making way:*
>
> *a.* ***Wind Speed and Direction****. SHOL wind speed and direction envelopes do not apply.*
>
> *b.* ***Limitations.***
>
> *(1)* ***Confined Area Limitations****. Normal ashore flight manual/Squadron SOP limitations are to be adhered to and the deck considered a confined area. Appropriate performance limits must be calculated taking into consideration that significant turbulence may be present …"*

72. **Operational utility evolutions.** The aforementioned reference details the regulations to be applied for operations to a ship not making way. The ABR 5419 regulations applicable to the assault evolution are found in annex D to Chapter 6 – *Operational Utility Evolutions*, which state:

OPERATIONAL UTILITY EVOLUTIONS

> *1.* ***Introduction.*** *Operational Utility, in the context of this publication, refers to a range of helicopter evolutions conducted to a ship that are not otherwise mentioned in this chapter. This may include, but is not limited to:*

a. *fast roping,*

b. *rappelling,*

c. *caving ladder extraction, and*

d. *suspended recovery operations.*

2. ***Rehearsals.*** *Such activities are operationally focused and may need to be rehearsed to establish or maintain a capability.*

3. ***Aviation Risk Assessment.*** *Due to the nature of these evolutions, there may be a requirement to conduct them to areas of a ship other than the flight deck or designated Transfer/VERTREP areas in order to simulate operational realism and challenge crew capabilities. Consequently, this involves a heightened risk and careful consideration must be given in the selection of the area and the conduct of the evolution. The application of Aviation Risk Management is essential to the safe and effective conduct of these activities.*

4. ***Conduct.*** *The actual conduct of the evolution shall be IAW individual Squadron SOP and will require:*

a. ***Briefing.*** *A thorough briefing of all personnel is required on what is essentially a non-standard flying operation for the ship.*

b. ***Access Management.*** *Close management of access to upper deck areas is required, particularly if the operation impinges upon those areas where personnel are normally permitted during Flying Stations.*

c. ***Flying Stations.*** *The ship shall remain closed up at Flying Stations throughout the conduct of Operational Utility Evolutions.*

d. ***Personnel.*** *FDT may or may not be required.*

5. ***SHOL.*** *Although specific SHOL are not promulgated for such evolutions, the designated target ship may be required to provide suitable wind and deck motion parameters to overcome limitations in areas such as power available and hover references. The aircrew are to establish these requirements, brief them appropriately before launch, and advise Command if the conditions are subsequently found to be unsuitable.*

NOTE

The evolution should, whenever practical, be rehearsed/conducted by day before being attempted by night.

73. **Flying stations requirements.** Chapter 10 para 3 of ABR 5419 vol 1, states the following (for operations to a ship at anchor/buoy or not making way):

> *"The ship is to go to Flying Stations and observe the usual safety rules and flight deck operating procedures and is to be fully manned as described in this publication."*

74. Chapter 6 Annex D para 1 of ABR 5419 states the following (for operational utility evolutions (including fast roping)):

> *"The ship shall remain closed up at Flying Stations throughout the conduct of Operational Utility Evolutions."*

75. Chapter 5 table 5.1 of ABR 5419 states:

> *"A ship's status may be reduced to "relaxed at flying stations" after aircraft have launched or when holding AL15*[11]*, or when nominated "spare deck", or otherwise requiring maintaining a flying posture to respond to an unscheduled recovery/HIFR. When relaxed at flying stations, personnel may be allowed to leave on a 'trickle basis' for short periods but be able to close up at short notice. All material preparations remain completed, Flight Deck Nets remain lowered and Flying Stations restrictions remain in force."*

76. **Ship's disposition.** At the time of the accident, the ship's flight operations status was "relaxed at Flying Stations" IAW ABR 5419. Conditions such as the ship's pitch and roll, at the time of the accident, were considered to be similar to those conditions recorded in the Helicopter Control Office (HCO) for the subsequent recovery of GOLD ONE and GOLD TWO one hour later. These were noted as pitch zero degrees and roll two degrees. (The ship's status at the time of the accident had been erased from the FLYCO status board and updated to reflect conditions for the recovery of the remaining three aircraft).

77. **Ship's heading.** As the ship was drifting, the ship's heading was not recorded in the log, however examination of flight data recordings of the remaining three aircraft and their approach directions determined the ship's heading at the time of the accident to be approximately 233 degrees true.

78. **Ship's drift**. A number of GPS fixes were noted in the ship's log prior to and after the accident. These were as follows:

a. Time 1600 hrs 18 44.99 S, 176 57.60 E;

b. Time 1614 hrs 18 44.89 S, 176 56.40 E;

c. Time 1624 hrs 18 44.80 S, 176 56.24 E; and

d. Time 1642 hrs 18 44.66 S, 176 59.11 E.[xxxiii]

79. The crew of BLACK TWO noted the GPS position of the accident as 18 44.786 S, 176 59.180 E.[xxxiv]

11 AL15 refers to the ship's readiness to launch or receive aircraft.

80. There are a number of inconsistencies with the figures in that the ship appears to initially drift to the west and then back to the east. The rate of drift also varies from 4.8 knots to 1.1 knot depending on which points are used. Furthermore, the position of the accident as noted by BLACK TWO is 2.6 nm different to that of HMAS KANIMBLA. The AAIT was therefore not able to conclusively state the rate of drift; however it was acknowledged that with a westerly sea current of 0.75 knots and an easterly wind of 10-15 knots, the ship would be expected to drift to the west. This was confirmed by the crew of GOLD ONE, who had noted that the ship had drifted approximately 400 metres to the west of the original GPS waypoint logged on departure some 30 minutes earlier.

Mission planning and orders

81. Up until the accident sortie, flying activities on OP QUICKSTEP had involved DLP, ship underway recovery assaults, ASBF, airborne formation rejoin practices and general tasking. These activities had been conducted to HMAS KANIMBLA and HMAS NEWCASTLE whilst underway.

82. Correspondence drafted by the S3 TE 636.2.1.3 on 28 Nov 06 highlighted the following aviation training deficiency and suggested remediation in Para 12 of SITREP 023/06.[xxxv]

> *"Analysis of trg conducted to date indicates a trg deficiency/lack of recency relating to assessment of rate-of-closure on static targets. This has been compounded by an inability to conduct training to 1 spot / forecastle area on the LPA (disallowed to the presence of ULP IVO 1 spot). IOT address this problem ship aslt trg to HMAS Newcastle has been programmed with a request for the vessel to halt during trg serials. At the time of writing the conduct of aslt trg to NEWC has been approved, however, it is the opinion of the XO NEWC that the vessel must be underway IOT provide "safe" winds across the deck. Further avenues are being pursued to dispel this misconception."*

83. To address the training/recency issue, the 171 Avn Sqn detachment programmed a specific training sortie to conduct continuation training to address the deficiency. As no land based targets were available, HMAS NEWCASTLE was requested to stop, therefore becoming a 'static' objective. The night prior to the assaults, HMAS NEWCASTLE assault training was cancelled due to the concerns of the Commanding Officer of HMAS NEWCASTLE regarding the wind over the deck limits, as well as, the re-tasking of HMAS NEWCASTLE. The training was reprogrammed to be conducted on HMAS KANIMBLA utilising the forecastle and aft flight deck. Subsequent mission planning, orders and presentations were prepared in accordance with the 5 Avn Regt SOP 407 *Special Operations Orders*.[12]

84. On 29 Nov 06, at the 'Flying Brief' (attended by the aviation and ship's command elements), it was reinforced that permission to operate to the forecastle had been declined, due to equipment and dangerous cargo stored on the forward flight deck. A 30 minute delay

12 171 Avn Sqn was utilising 5 Avn Regt SOPs until such time as their own SOPs were developed. This was directed in the *Interim Command Responsibilities – 16 Bde (Avn)* HQ16BDE/OUT/2004/1240 Directive dated 2 Dec 04.

to facilitate amendments to the mission packages and presentations was directed and the revised documentation was issued at the orders group. The authorising officer, aircrew and selected squadron personnel attended the orders and a mission rehearsal and walk-through was conducted on completion. Mission orders and packages were presented IAW SOP.

Carriage of passengers

85. The AAIT was advised by CO SASR that non-essential personnel were not to be carried on operational training flights. All passengers aboard BLACK ONE were SO qualified and had conducted RW training in the previous 48 hrs and therefore met the briefing requirements of SI (AVN) OPS 3-201 – *Carriage of Passengers.*[xxxvi] The coordination for the inclusion of the passengers in the mission was discussed the previous night between the 171 Avn Sqn S3 and the 1 Sqn Tp SGT. The intent was to conduct concurrent training for SO Air Safety Officers (ASO) and SS supervisors and was only to be conducted when it did not interfere with the conduct of the aviation training. Those that were to conduct the training did not attend orders and there is no evidence of a formal mission sortie briefing with the SO FE prior to the sortie.

86. Although the passengers were not in attendance at orders and there was no indication of passengers in the written mission orders, all the aircraft captains and the authorising officer were aware of the inclusion of SO troops in the sortie and the intent to conduct opportunity training in air safety officer (ASO) and sniper safety (SS) calls. There are indications that CAPT Bingley did discuss the sortie profile with the passengers in his aircraft prior to departure. However, the AAIT was unable to determine the level of coordination between operations staff and the flight crew regarding the planning, briefing and carriage of passengers.

87. The AAIT noted the following issues relating to the carriage of passengers:

a. at least one passenger did not have his sleeves rolled down as required in SI (AVN) Ops 3-201; and

b. electronic devices (specifically unit video cameras) were being used to record training evolutions. The AAIT did not establish whether the use of this equipment was in accordance with SI (AVN) Ops 3-103 – *Use Of Non-Standard Electronic Equipment.*

Pre-departure passenger loading

88. Prior to departure, a number of SO troops approached GOLD ONE's aircraft. The aircraft captain ascertained that these personnel were not programmed to fly with GOLD ONE in accordance with the orders and the intent of the sortie. The AAIT understanding is that a discussion took place between the SO Tp SGT and the crew of the BLACK formation, who indicated that they would take the SO personnel and, in an effort to conduct concurrent training, would integrate their requirements into the sortie.

Flight authorisation

89. The flight was authorised by the Detachment Commander, and included the following sequences:

a. Serial 1 – Hovering, circuits, steep take-off and approach, running take-off and approach, confined areas, slopes, internal/external loads and hoisting.

b. Serial 3 – Terrain flight.

c. Serial 4 – Formation flying.

d. Serial 5b, 5c and 5i – Ship operations, roping and ABS.

Orders and procedures

90. The 5 Avn Regt SOPs applicable to the operation were:

a. SOP 401 Airmobile Support to Special Operations Forces,

b. SOP 407 Special Operations Orders,

c. SOP 408 Special Operations Mission Package, and

d. SOP 409 Domestic Operations in a permissive environment.

91. The SOPs do not provide specific guidance on the technique to be employed; this is found in the SO Techniques lecture, which is part of the Special Operations course. The SO qualification course is conducted IAW an approved Course of Instruction (COI). At the time of this report the COI had been transferred to the AAvnTC awaiting amendment and acceptance as a training management package (TMP).

Finding. The TMP for the SO course is not finalised.

92. The SO assaults use a combination of the quickstop manoeuvre, as defined in the Black Hawk Standardisation Manual, and the parameters and gates as defined in the SO Techniques lecture.

93. Extracts of AAP 7210.015-16 Black Hawk Aircraft Standardisation Manual describes the quickstop manoeuvre as follows:

"Quick Stop

31. Terrain flight manoeuvring involves acceleration and deceleration of the aircraft to achieve the mission. The primary deceleration technique is the quick stop which, for the purposes of standardisation, is taught in three forms:

a. into wind;

b. turn and flare; and

c. flare and turn.

32. For all quick stops, the aircraft should not be allowed to descend until the FP makes a conscious decision to do so."

94. Following on:

*"36. **Flare and Turn Quick Stop**. The flare and turn quick stop is initiated by the FP flaring the aircraft by reducing collective and applying aft cyclic. The turn is then initiated with cyclic. As the aircraft decelerates towards ETL power must be applied to terminate the manoeuvre.*

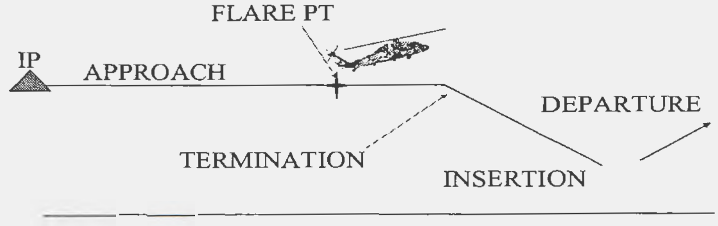
*37. **Termination of Quick Stops**. The manoeuvre may terminate in an OGE or IGE hover, hover taxi, or be flown to the ground, and could form the termination segment of a terrain flight approach.*

38. The quick stop has no strictly defined entry and exit parameters, nor change of direction; it is adapted to meet the situation at hand. The above quick stop techniques are the basis of all decelerative manoeuvres and may be employed in any combination to achieve the desired outcome."

SO Techniques lecture

95. The SO technique lecture forms part of the SO course given to new aircrew members of 171 Avn Sqn. The lecture covers aspects of the training necessary to conduct SO operations. An extract of the lecture applicable to the investigation, in particular the assault evolution, is discussed in the following paragraphs.

96. The assault approach is broken into four phases (shown at figure 12); the approach, termination, insertion and departure. The phases of the procedure applicable to the investigation were the approach and termination.



Figures 15. Four phases of assault approach

97. In reviewing the presentation, the approach phase is flown with the following parameters:

- *Airspeed 80 -100 knots indicated airspeed (KIAS).*
- *Height 100 ft above height of obstacles (AHO).*
- *Formation – tactical.*
- *Formation changes after the IP – maybe.*
- *Power requirements - Category 4 (OGE + 5%).*

98. Selection of the flare point occurs prior to the termination and uses the following formula:

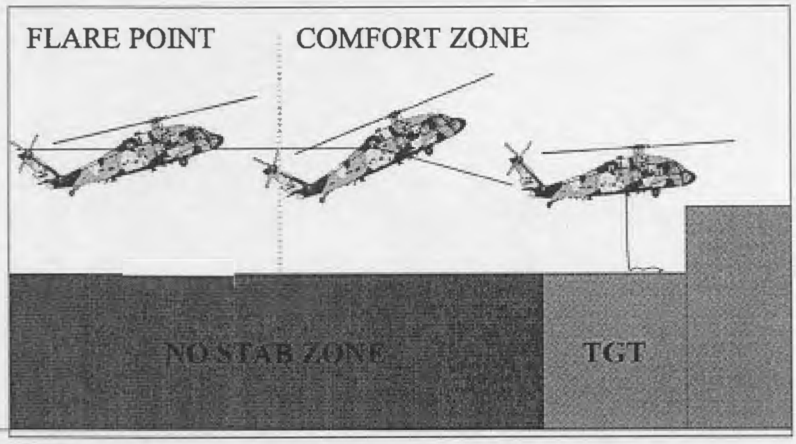
> *"800m from the target plus or minus 100m for each 10 knots tail/headwind component, 100 ft climb or descent and each 1000 ft AMSL."*

99. A final gate of less than 80 knots at 300 metres to the objectives is employed.

100. The Termination phase (shown at figure 13) is defined as:

- *Multi angle, non-linear deceleration (quickstop) to the nominated LP.*
- *Aim - To position for the insertion.*
- *As fast as possible but **First Strike**.*
- *High workload - crew co-ord intensive.*

The Termination



Figures 16. Assault termination

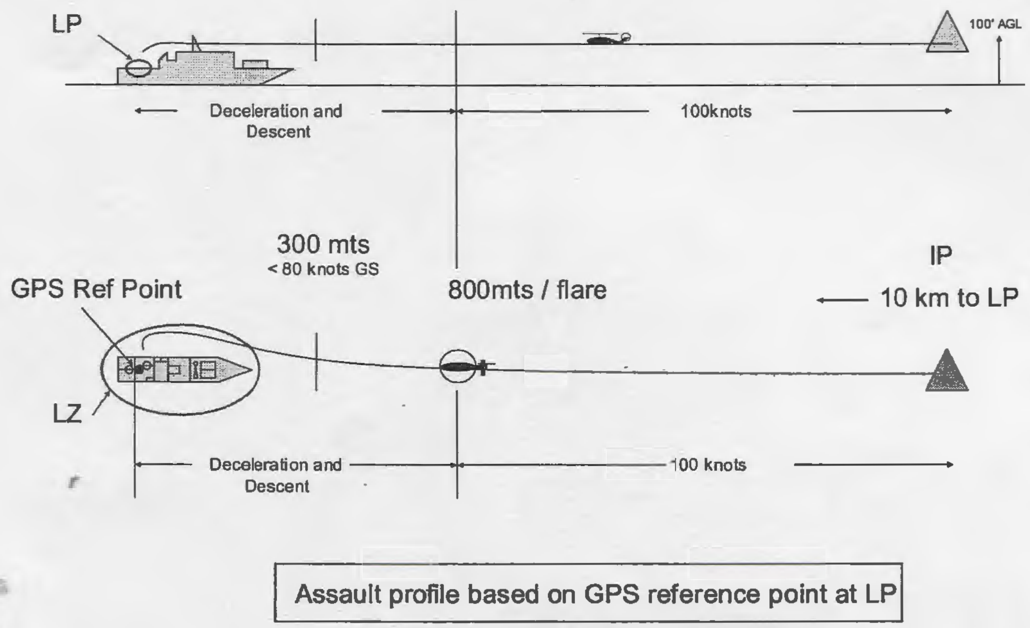
101. A description of the procedure from the briefing notes is as follows:

"The termination commences at the flare point and is a multi angle non-linear decelerative quickstop to the nominated LP. It is conducted as fast as possible and, if fast-roping, the aircraft will need to be as low as possible for the insertion, however should not be less than about 15 ft. The flare is sedate initially, and developed more aggressively at the end. 80% of the aircraft energy is lost in the last 20% of the approach."

102. The briefing notes describe a "comfort zone" at the end of the flare as follows:

"¾ of the deceleration in the termination is conducted in the last ¼ of the distance. As you approach the last ¼ of the distance to run you enter the "comfort zone". As you approach the comfort zone you must be at a height and groundspeed combination that you can guarantee successful termination over the LP."

103. The accident sortie as planned, with the ambient conditions, is shown at figure 14.



Figures 17. Normal approach parameters

DSTO analysis of CCTV recorded information

104. **HMAS KANIMBLA CCTV.** Camera footage from HMAS KANIMBLA was collected and underwent analysis by DSTO contained in their independent report (reference B). Significant results obtained from the footage follows:

a. The aircraft passes abeam the ship on final approach to the objective with an initial average speed of 98 knots, slowing to 80 knots as the aircraft disappears from camera view (abeam the forecastle, which is approximately 104 +/- 18m to the objective) with a fuselage spacing of approximately 38 +/- 3m (which places the rotor tip approximately one and a half rotors spans from the ship). Height above sea level was 28+/-3m (92 +/- 9 ft)

b. The rate of descent (ROD) and speed at the time of impact was 1300 feet per minute, 21 knots horizontal and with a nose-down pitch angle of approximately 20 degrees.

c. The wind just prior to the accident was categorised as force 4 on the Beaufort scale, which corresponds to a speed of between 11 and 16 knots, at 10m above sea level. The wind direction is variable, appearing to fluctuate between 90 and 135 degrees from the bow, on the port side of the ship. At the time of the accident, the wind appeared to be at the high end of the force 4 category, from approximately 110 (+/-10) degrees relative to the ship's heading.

105. **Cockpit voice recorder from BLACK TWO.** The cockpit voice recorder (CVR) recording from BLACK TWO was downloaded and analysed by the AAIT. The sortie profile of BLACK TWO and crew comments made about the position and intent of BLACK ONE were consistent with that which would be expected for the sortie prior to the accident. There were no unusual comments made about BLACK ONE as it commenced the run-in and up until the accident. However, the CVR did record the activation of the Crash Position Indicator (CPI) on BLACK ONE as it collided with the deck of HMAS KANIMBLA. The duration of the CPI activation was 4.5 seconds, indicating the approximate time from impact to submersion of the CPI antenna located on the upper fuselage.

106. **Flight data recorders (FDR).** The flight data recorders from the remaining three Black Hawks were downloaded and analysed by the AAIT. Data obtained from the recordings was as follows:

a. average aircraft heading enroute to the ship was 041 degrees magnetic (therefore indicating the ship's heading was 221 degrees magnetic).

b. Pitch and roll of the aircraft just prior to takeoff was +/- two degrees of roll and +/- one degree of pitch (the inference is that this represents the ship's pitch and roll approximately one hour before the accident).

107. **Hand-held digital video cameras.** Two hand-held digital video cameras were carried by SO personnel on the formation aircraft. One camera on each of BLACK ONE and BLACK TWO. The footage from BLACK TWO was analysed by the AAIT and found to contain limited information relevant to the investigation. The camera on BLACK ONE was recovered following the accident and forwarded to DSTO for analysis. The film was significantly affected by salt water and the recovered video footage only provided imagery of personnel in the cabin of the aircraft, and some video of the flight up to the point where the run-in commences from the IP to the ship. Throughout the available video aircraft operations appear normal. Measurements obtained from the final useable frame of footage, when the aircraft was approximately 203m from the bow of the ship (see figure 1) indicated that the aircraft was offset from the ship by 20+/- 3m and at a height above sea level of 37+/-4m (121 +/-13 ft).

The Sikorsky S-70A-9 Black Hawk A25-221

108. The accident aircraft was a Sikorsky S-70A-9 Black Hawk helicopter A25-221. The aircraft had accrued 3428.8 hours (AFHR).

109. All servicings had been carried out as per the Technical Maintenance Plan, AAP 7210.015-7, and recorded in the aircraft documentation. Rectifications for the period prior to the accident had been limited to a minor radio unserviceability and Special Technical Instruction inspections.

110. An S57 service for a Main Rotor Hub Spindle and Drag Beam Inspection was due on the day of the accident. The servicing was scheduled to be performed at the completion of the day's flying, which was within the allowable elapsed day limits.

111. **Carried forward unserviceabilities (CFUs).** CFUs were authorised and considered to have no relation to the accident.

112. Inspection of the aircraft maintenance documentation and statements provided by maintenance personnel indicated that the aircraft was operating to a satisfactory standard with no maintenance issues or outstanding rectifications.

113. **Weight and balance.** A weight and balance calculation, based on load information provided by the accident crew, indicated that the aircraft departed with an all-up-weight of 17,773 pounds (maximum allowable 22,000 pounds) and a centre of gravity 359.4 inches aft of the datum (allowable 341.7 to 363.1 inches). At the time of the accident, approximately 15 minutes after take-off, the all-up-weight would have been approximately 17,500 pounds with a moment arm of 358.9 inches.

114. **Black Hawk flotation.** The Black Hawk is not fitted with aircraft flotation devices, such as those fitted to the Seahawk.

FLIGHT CHARACTERISTICS

Collective to pitch mixing

115. A component of the Black Hawk helicopter relevant to the investigation is the Mechanical Mixing Unit (MMU). The MMU assists with the control of the helicopter by minimising pilot workload. One of the functions is to provide increased forward disc input with increases in collective, and vice versa. This compensates for changes in downwash over the rear of the airframe with changes in power. Essentially, this flight characteristic will result in a nose-down pitch of the helicopter during an increase in collective, particularly at airspeeds of less than 30 KIAS, where the stabilator is in the full-down position and not providing any pitch-up moment. (It should be noted that in an out-of-balance turn, the rotor downwash over the rear airframe will be less and this will therefore increase the effectiveness of the collective to pitch mixing).

Main rotor droop

116. Main rotor droop is referred to as a reduction in main rotor revolutions per minute[13] (RPMR) below that which the manufacturer has designated as the optimum for that particular helicopter and flight condition. Rotor droop occurs when the aerodynamic loads on the rotor system are exceeded. The droop can be transient, where short term demands on the rotor system are momentarily exceeded or it can be static, where the engine(s) do not have sufficient power to meet the long term demand of the rotor system.

117. The effect of rotor droop is to reduce the thrust from the rotor system; and depending on the degree and duration of the droop, can produce a rate of descent and reduced control effectiveness.

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13 AAP 7210.015-1 S-70A-9 Black Hawk Flight Manual denotes main rotor revolutions per minute as RPMR.

118. The following is an extract from AAP 7210.015-1 S-70A-9 Black Hawk Flight Manual:

> *The T700 engine control system accurately maintains 100% RPMR throughout the flight envelope for most manoeuvres. However, pilots should be aware that certain manoeuvres performed with minimum collective applied will result in significant transient rotor droop. High density altitudes, heavy gross weights and operation at less than 100% RPMR will aggravate this condition. During descent with little or no collective applied, Ng will be less than 80%. If RPMR increases above 100%, the ECU torque motor input to the HMU is trimmed down in an attempt to restore 100% Np and RPMR…….*
>
> *"…….Manoeuvres that rapidly load the rotor system with no collective input can result in transient droops as low as 92%. Transient droop is more pronounced at higher altitudes since the HMU reduces Ng acceleration as barometric pressure decreases. To minimise transient rotor droop, avoid situations which result in rapid rotor loading from low Ng and torque conditions. Initiate manoeuvres with collective inputs leading or simultaneous to cyclic inputs. During approach and landing, maintain at least 15 to 20% TRQ and transient droop will be minimal as hover power is applied."*

119. Furthermore a 'WARNING' in the flight manual states:

> *"Rapid application of collective from very low power settings, especially if the rotor and Np have split, may result in transient rotor rpm droop to 90% RPMR and below. This transient rotor droop will result in increased coning angles and decreased control response. Apply collective judiciously until RPMR and Np indications are joined."*

120. The Black Hawk is fitted with a visual and aural warning system to alert the crew of this condition.

121. A number of SO Black Hawk aircrew indicated that they had experienced rotor droop in the Black Hawk during SO approaches, with one member indicating that transient reductions down to 90% of RPMR had occurred. During this time manoeuvrability in all three axes was momentarily degraded. In each case the rotor rpm recovered and the aircraft eventually settled into a stationary hover over the objective. This condition is likely to be exacerbated where the approach to the objective is flown with higher airspeeds (requiring more sustained decelerations), high aircraft all-up-weights and during less than favourable ambient conditions such as a tail-wind and high temperatures.

> **Finding.** The SO assaults, as carried out by 171 Avn Sqn, may place the aircraft in a flight regime where the flight manual 'WARNING' states that transient rpm droop may result.

Vortex ring state

122. The AAP 7210.015-1 S-70A-9 Black Hawk Flight Manual states:

> *"Flight conditions which may result in vortex ring shall be avoided at low altitudes because of the altitude loss required during recovery. Vortex ring state describes an aerodynamic condition where a helicopter may be in a vertical or near vertical descent with power applied and little or no cyclic authority. Vortex ring is possible at descent rates above 700 FPM and airspeeds from 0 to 20 KIAS and is likely at descent rates of about 1 500 FPM and airspeeds of 5 to 10 KIAS. Vortex ring may also be encountered during any dynamic manoeuvre which places the main rotor in a condition of high upflow and low longitudinal airspeed."*

Simulator trials

123. Simulator trials were conducted on the DSTO S-70 Black Hawk flight model simulator at Fisherman's Bend, Victoria and the S-70 full flight and mission (FF&MS) simulator at Oakey, Queensland.

124. The known ambient conditions were preset into the simulators, along with the assumed aircraft weight and c of g position. The graphics presented to the operating crew was that of a RAN Landing Platform Amphibious (LPA) in open water. The crew were briefed to follow the flight path of BLACK ONE, utilising known airspeeds and heights extracted from the ship's CCTV footage including using an offset GPS reference point for distance guidance as per the accident sortie. The approach was flown from bow to stern, on the port side of the vessel, terminating athwartships facing starboard. The approaches were flown by the unit senior standards officer, who is in current flying practice and familiar with the sequence.

125. Findings of the Oakey trial were as follows:[xxxvii]

a. As the aircraft passes abeam the ship, modest collective reduction is required during the final stages of the flare in order to prevent the aircraft from climbing and to complete the final descent prior to the turn. Left pedal is progressively required in order to orientate the aircraft nose in the direction of termination. As the termination point is approached, left cyclic is increased to reduce the rate of closure (approx 45 degrees angle of bank (AOB)) and as the superstructure is cleared, forward cyclic is introduced to move forward towards the aft flight deck. At this time, as lateral speed reduces, collective is increased to reduce the rate of descent and position the aircraft at the termination height above the deck. At this point full collective input is insufficient to reduce the rate of descent. As the deck is approached, aft cyclic is introduced to assume the termination attitude but is ineffective. The aircraft then pitches nose down noticeably, not violently, but such that impact with the deck is unavoidable, in a nose down, close to wings level attitude at approximately 20 knots.

b. The **LOW ROTOR RPM** warning light and audio activated in the final seconds prior to impact, however, the activation was at a stage where impact was inevitable.

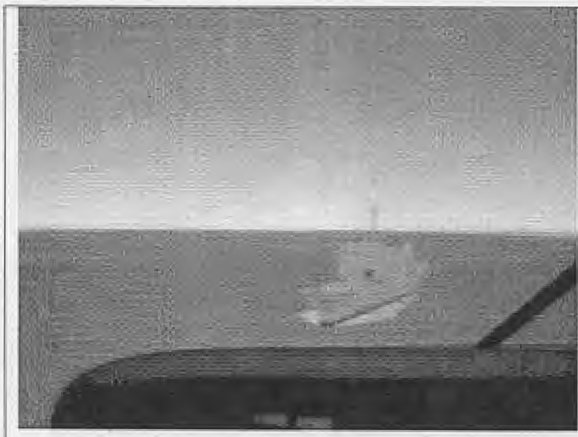
c. Time period from minimum collective (during the flare) to maximum collective (at the time of impact) was 6.7 seconds.

d. Time period from the minimum collective position to re-application and the point at which RPMR was at its lowest was 1.1 seconds.

e. The RPMR recovered to normal parameters within three seconds of reaching the lowest point.[14]

f. In order to evaluate crew and aircraft response, aircraft emergencies were introduced at a critical phase in the approach (during and prior to the left turn). These included engine failure, engine control unit overspeed/underspeed, tail rotor control malfunctions and power restrictions (simulating a jammed collective). On each of these occasions the aircraft did not follow the final flight parameters as obtained from analysis of the CCTV recording. Depending on the emergency, a go-around was either possible or the aircraft impacted the aft flight deck but with a rate of descent and forward speed that was noticeably reduced when compared with the unrestricted profile at sub-paragraph a.

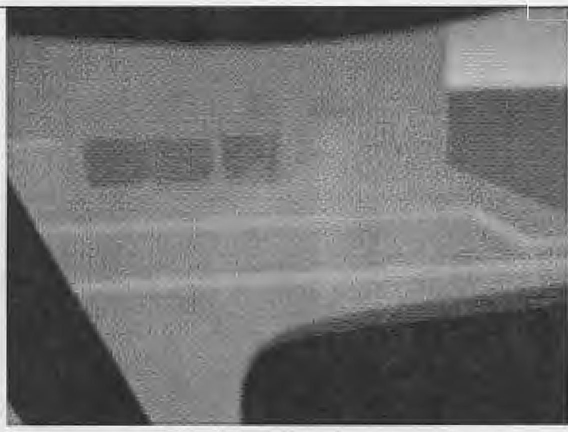
14 The graphs obtained from the trial indicated that RPMR only reached 97%, however for the Low Rotor RPM warning to activate the RPMR must fall below 95%. This was considered to be a calibration issue between the simulator and the software readout.



Commencement of the flare approx 500 metres to the objective.

Commencement of final flare and turn.

Commencement of skidding turn.



Final attitude and heading over objective, before impact.

Figures 18. Oakey Black Hawk simulator images of accident sequence from left pilot station

126. The DSTO flight dynamic model (simulator) is a high-fidelity Black Hawk model developed using the FlightLab framework. The non-linear mathematical model is a total systems definition of the Black Hawk helicopter represented at the level of sophistication necessary for conducting handling quality evaluations. It uses an empirical model to flag and simulate the vortex ring state during manoeuvring flight.

127. The DSTO simulation runs were conducted to recreate flight profiles that model what was known about the incident and investigate the sensitivity of the accident conditions to various flight parameters. Although the simulation model flagged the entrance into a vortex ring region during final flare and turn in, further analysis was needed to determine its severity. Analysis of horizontal and descent parameters with comparison to a typical

helicopter vortex ring boundary shows that the flight envelope was unlikely to have entered a completely developed vortex ring state. At most, the simulation shows that the outer vortex ring state boundaries may have been breached, causing some turbulence and thrust variation.

128. Subject matter experts at DSTO noted that "*the flow conditions associated with the vortex ring state are highly complex. Although such a state is modelled, there is no guarantee that entering the vortex ring envelope during simulation is evidence of its occurrence during the incident.*"[xxxviii]

129. A follow up simulator trial was carried out at DSTO, Melbourne to evaluate the effects of varying the wind component, aircraft AUW, spacing and approach airspeed. The results of this trial are shown in the following table:

Serial	Changes	Results	Observations	Comments
1.a. Wind	Wind changed to **No-wind**	Aircraft Impacted the deck but slightly earlier.	Aircraft had a higher groundspeed and was more difficult to slow down in later stages of approach	Still required a high AOB to achieve aim point and application of power in the turn and after levelling
1.b.	**Wind** changed to Green 135 (Equivalent headwind component)	Aircraft did not impact deck.	No apparent sink or loss of control and the ability to conduct go around or continue to insertion point was proven.	Still required significant AOB but less up collective during the transition from approach. No apparent sink rate at termination.
2. Lateral distance	**Lateral Distance** increased to >2 rotor diameters from LPA during approach	Aircraft was able to avoid deck and conduct go around	Pilot has more visual cues during the turn and is able to use less AOB. A noted transition between the flare/decel and then level to approach over the deck to the landing point.	Pilot has greater time to view and assess his closure rate and react to these visual cues. Less AOB required, but similar power requirements.
3. Groundspeed Changes	Decrease in **GS** > 5 KNOTS	Aircraft did not impact deck	Less decel required and therefore less AOB to make	Less AOB is required to transition from approach and

			landing point	turn to terminate
4.Weight	Decreased **AUW** 1000 lbs (approx weight of five passengers)	Aircraft did not impact deck No apparent sink rate and good potential to complete insertion/conduct go around	Less inertia and therefore greater ability to decel early resulting in less AOB and power	As above / less power required and therefore a greater power margin.

Table 5. Outcomes of simulator trials

130. A summary of the findings from the follow-up simulation at DSTO were as follows:

a. In a no-wind scenario, impact with the flight deck still likely. In a headwind scenario, impact with the deck was avoidable.

b. Any variations in the profile reduced the likelihood of impact with the flight deck. These were:

(1) A flight path greater than 2 rotors diameters (35 metres) from the objective,

(2) An approach with a groundspeed 5 -7 knots slower, and

(3) 1000 lbs less AUW (the weight of five passengers).

Finding. From the simulator trials, a combination of a late flare and deceleration, terminating into the hover with a tailwind, reduced lateral spacing from the objective and increased all up weight during the assault manoeuvre, affected the outcome.

Witness statements

131. A significant number of personnel witnessed portions of the events involving the accident of A25-221. Statements were provided and analysed by the AAIT. There were some minor inconsistencies. However, observations that were consistent and/or corroborated by other sources of data, included the following:

a. BLACK ONE appeared to be faster on its approach when compared with the approaches made by the GOLD formation.

b. The westward drift of the ship was noticed by personnel located on various decks.

c. Personnel aboard the aircraft indicated that an audible change in engine/rotor pitch occurred during the accident sequence. Note: The AAIT could not confirm these without collaborative recorded sounds.

d. Personnel involved in the rescue and recovery confirmed the initial location of survivors, their condition and order of recovery.

132. Separate comments made by aircrew that had flown with the aircraft captain on previous occasions indicated that he was dissatisfied with some aspects of his SO approach accuracy. This related to *ship underway recovery assaults*. In particular, on the previous night sortie, the aircraft captain found that he was terminating in the hover somewhat short of the objective.

PRELIMINARY TECHNICAL ANALYSIS

133. At the time this report was released, the bulk of the wreckage, CVR and FDR were not available for examination. The AAIT was however, able to analyse various elements of CCTV footage, FDR recordings from the remaining Black Hawks, along with ship's records and witness statements. The AAIT then considered those factors and scenarios that would have placed the aircraft into the parameters as recorded on the CCTV and as described at paragraph 104.

134. The first consideration was to determine whether or not the aircraft was under control of the pilot during the accident sequence. Control of an aircraft is where the mechanical and aerofoil surfaces respond to control inputs from the handling pilot coupled with the aircraft reacting to movement of those surfaces. A transient or partial loss of control effectiveness may occur while the aircraft is overcoming aerodynamic conditions that prevent such response, such as when the airflow over an aerofoil surface is disturbed. A full loss of control occurs where the handling pilot is no longer making any inputs or when the aircraft no longer responds to those inputs, such as failure or disconnection of any control system.

135. In considering the hypothesis regarding aircraft control, the AAIT investigated a number of possibilities.

Handling pilot input

136. The AAIT was satisfied that the handling pilot was capable of providing control inputs throughout the sequence based on the following:

a. simulator trials demonstrated that full control inputs were required in order to achieve the flight path recorded on the ship's CCTV,

b. the pilot was rescued with his HABD mouthpiece in his mouth and his LPSV fully inflated, and

c. the lack of medical evidence to suggest pilot incapacitation prior to impact.

Control or system failure

137. As stated in the DSTO report at reference B, "mechanical failure is considered unlikely based on the behaviour observed during the Oakey simulation trial where a number of mechanical failures were examined and failed to lead to conditions close to those indicated

by the video footage of the accident". Additionally, statements by the surviving aircrew did not indicate that any power or control restrictions were evident prior to impact.

Aerodynamic forces

138. The AAIT further considered those aerodynamic forces which may have contributed to the accident, specifically Vortex ring state and main rotor rpm droop.

139. **Vortex ring state**. Theoretical modelling of vortex ring state was incorporated into the computer code of the Black Hawk simulator at DSTO. During the DSTO simulator trials, the theoretical regime for vortex ring was marginally approached and considered to be of no consequence to the aircraft performance. As with the DSTO simulator trials, it was possible to estimate how close to the theoretical vortex ring envelope the aircraft was during the Oakey simulator trials.[15] The subsequent analysis by DSTO of the Oakey trial data, when assessed against the DSTO modelling, resulted in the aircraft entering the conditions for vortex ring state during the final descent into the ship. However, as stated in reference B, "*it must be clearly noted that the flow conditions associated with the vortex ring state are highly complex. Although such a state is modelled in the DSTO simulation, there is no guarantee that entering the vortex ring envelope during simulation is evidence of it happening during the incident*."

140. **Main rotor rpm droop.** During the Oakey simulator trials, main rotor rpm droop occurred approximately five to six seconds prior to impact. For this droop to occur, a collective application was required which resulted in the RPMR reaching its minimum rpm within one to two seconds of the collective application. This collective application occurs after the aircraft has completed turning toward the objective. Had the collective application and droop occurred earlier in the sequence, the accident flight path as recorded on the ship's CCTV would not have been achieved. By applying collective any earlier, it is likely that the aircraft would overshoot the objective whilst still in the turn and flare (impact with the ocean may still have occurred).

141. The AAIT believes that RPMR droop occurred during the accident sequence. The RPMR droop was a result of the combination of the following factors:

a. a significant reduction in collective to initiate the required decelerative flare, which unloaded the rotor disc resulting in an increase in the main rotor rpm,

b. the characteristics of the HMU which most likely spooled the engines down to a low Ng, and

c. the collective application at the completion of the flare and turn.

142. These factors would have contributed to the aircraft developing a high ROD.

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15 The Black Hawk simulator at Oakey was initially programmed to include vortex ring state in its flight profiles, however during 2000/2001, aerodynamicists from Canadian Aircraft Electronics Inc (the manufacturer of the Black Hawk simulator) verified that the condition is improbable in the Black Hawk. The condition was therefore removed from the simulator and applicable training packages.

143. In the Oakey simulator trial, the RPMR was noted to recover within three seconds. If the trial was an accurate replication the accident flight, then the recovery of the RPMR is consistent with the manner in which BLACK ONE lifted off from the flight deck after impact and reaching a height of approximately 10 ft before rotating over the starboard side of HMAS KANIMBLA. This would have been unlikely had the rotor rpm not recovered to normal parameters.

> **Finding.** On the balance of probability, the aircraft was serviceable at the time of the accident, vortex ring state was not an initiator of the descent, and rotor rpm droop occurred at the completion of the flare and turn.

Flight profile

144. Examination of the factors affecting the flight profile indicated that the aircrew encountered a number of conditions which would have affected the flight profile.

Wind component

145. As indicated at paragraph 104.c, the wind component with respect to the initial run-in was a right quartering headwind of 10 to 15 knots. This would have had a positive effect in slowing the aircraft in preparation for the approach. With the aircraft captain cognisant of the previous sorties and the issue of arriving short of the objective, he may have considered delaying the deceleration in order to avoid undershooting the objective.

146. As the aircraft commenced to turn left toward the objective, the wind component would now become a tail-wind. This would have had the effect of pushing the aircraft toward the objective, therefore reducing the space available to complete the turn and deceleration. Further effects of a tail-wind are:

a. more power required to hover;

b. a tendency to pitch the aircraft nose down; and

c. with the increased power requirement, the effect of the collective to pitch mixing would be greater, thus further exacerbating the nose down pitch.

147. Ship's CCTV footage of the port side of the ship, immediately after the accident, shows smoke from a marker in the ocean producing a trail of smoke up and over the aft flight deck. The smoke trail is seen to follow the vortices that are being generated on the port side of the deck. These vortices are rising approximately two metres above the deck. The AAIT considered that these vortices are not rising high enough to affect the final outcome of the approach and was subsequently discounted.

Drifting objective

148. During the time interval from when BLACK ONE departed to arriving at the objective, the ship had drifted westward approximately 200m (based on the 400m of drift noted by GOLD ONE in 30 minutes). This would have had the effect of reducing the apparent distance to the objective. Figure 19 is a diagrammatic representation of the apparent waypoint

distances versus actual distances. The aircraft captain may have believed that at the nominated flare point of 700m to the objective (a headwind component of 5-10 knots had been factored in), there may have actually only been 500m remaining and similarly at the 300m gate there may have only been 170m to the objective. Whilst the approach is flown as a visual approach, with guidance cues from the GPS, judging the closure rate to the ship from the bow for the first time would have been somewhat different from an astern approach (as previously flown).

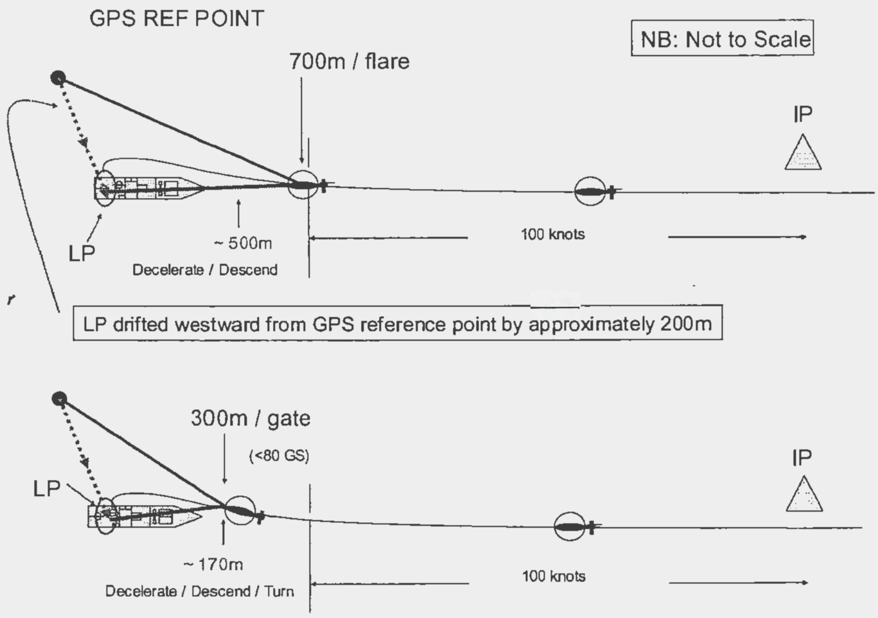

Figure 19. Diagrams of the drifting ship locations

149. **Static versus moving objective.** On previous sorties during OP QUICKSTEP, all approaches had been conducted to a moving objective i.e. ship underway. The dynamics of this is that the final airspeed of the aircraft needs to take into account the cumulative effect of the ship's speed, as well as, any wind component. At times this could mean an arrival speed of 20 to 40 KIAS. The aircraft attitude and power requirements between a zero speed hover and a 20 to 40 KIAS hover taxi is noticeable, where the zero speed hover requires a more nose-up attitude and more power.

150. **GOLD formation.** Having considered those factors which affected the profile of BLACK ONE, the question arises as to why the GOLD formation was not similarly affected. There were three elements in the differences between their approaches. Firstly, the GOLD formation became aware of the ship's drift (whilst passing the ship enroute to the IP and whilst awaiting the departure of the BLACK formation), and were therefore able to take this into account during their approach. Secondly, their termination into the hover was into a 10-15 knot headwind (which requires less power and pushes a turning aircraft away from the ship, therefore providing more room to complete the turn). Thirdly, the AUW of these aircraft were approximately 1000 pounds less than the aircraft of BLACK formation resulting in less power required.

SEQUENCE OF EVENTS

151. The likely sequence of events was as follows:

a. The mission was planned the day prior to the accident IAW with SOP.

b. The mission was briefed on the morning of the accident with amendments to the original plan (a half-hour delay was required to incorporate the late change to the objectives - removal of HMAS KANIMBLA forecastle as an objective).

c. On the flight deck a discussion occurred between the SO personnel and GOLD formation regarding their carriage on the sortie, which was denied by the leader of GOLD formation. BLACK formation resolved the issue of carriage of SO personnel and incorporated this concurrent activity into their sortie.

d. GOLD formation departed as briefed and awaited the departure of BLACK formation.

e. BLACK formation departed and then GOLD formation completed their first assault serial.

f. After BLACK formation departed and joined up in trail, BLACK ONE commenced to run into the ship with an initial target speed of 100 KIAS and 100 feet AGL.

g. Three minutes from the objective the aircraft captain of BLACK ONE nominated the port side of the ship as the active side, making him the handling pilot, and began to position the aircraft such that it could fly down the port side of the ship.

h. Approaching what the aircraft captain believed to be 700m from the objective (more likely 500m due to ship's drift), deceleration commenced.

i. As the aircraft passed abeam the bow, airspeed had reduced to approximately 80 knots groundspeed, which was faster than the guidance for the procedure in the training package (for distance to go to the objective).

j. At some point after passing the bow, the aircraft captain commenced the final deceleration and turn toward the objective.

k. In order to achieve alignment with the objective, left cyclic was increased while left pedal was introduced. The aircraft began to skid in the turn.

l. At this time, as lateral speed reduced and aircraft alignment with the objective was achieved in a nose low attitude, collective was applied in order to hover the aircraft at the termination height above the deck.

m. RPMR drooped as collective was applied and the aircraft pitched further nose down.

n. As the deck was approached aft cyclic and full collective were applied to assume the termination attitude but were ineffective in arresting the ROD.

o. The aircraft impacted the deck in a 20 degree nose down attitude, with 12 degrees of left bank at 21 knots of groundspeed and 1300 ft/min ROD.

p. At the point of impact, the fuselage struck the aft flight deck area, and the tailboom struck the port edge of the deck and separated from the fuselage.

q. The tailboom, complete with tail rotor, departed over the port side of the ship while the main fuselage section became airborne and commenced to rotate clockwise whilst traversing laterally across the deck.

r. The fuselage continued to rotate over the starboard side of the ship until it impacted the water and rapidly sank.

EMERGENCY RESPONSE

Initial search and rescue

152. At the time of the accident, an SAS dive exercise had just been completed and the K1 RHIB was at the port officer of the day (OOD) location off-loading divers. The K1 RHIB immediately slipped and proceeded aft to the starboard side and began retrieving survivors. The K1 RHIB had on board 2 crew, the dive supervisor, 5-6 divers, and a DFAT female civilian. The divers still on the K1 RHIB donned their fins, entered the water and assisted survivors onto the K1 RHIB. As survivors were surfacing on the port side, some of these divers, and others who had entered the water from the ship began to aid them. TPR Shephard was assisted by one SAS diver who called for someone to check the other life preserver. The seemingly empty vest (CAPT Bingley's) was noticed at about 4.5 mins after the initial impact, with one SAS diver discovering CAPT Bingley's head was below the life preserver and the water line. The life preserver was fully inflated and on the water's surface. Two more SAS divers swam to CAPT Bingley, and they all attempted to keep his head above water. It was noted he still had the HABD mouthpiece in his mouth, but no regulator, air line or HABD bottle. CAPT Bingley was not breathing and the SAS divers were unable to find a pulse. The SAS divers were unable to perform any effective CPR due to the position of the life preserver, and the difficulty just keeping his head above the water. They called out to the K1 RHIB to indicate the urgency to collect CAPT Bingley and that they could not find a pulse. CAPT Bingley was collected by K1 RHIB at approx five minutes following the initial impact. At this time the K2 RHIB was in the process of being launched. Once the K2 RHIB was launched, K1 transferred casualties and passengers to K2. K2 then proceeded to pick up TPR Oliver.

153. The likely order of collection of casualties from the water by K1 and K2 RHIB is as follows (witness statements and photos):

Rank/Name	Picked up by	Order Picked up by RHIBs	Transferred to
TPR Wilson	K1 RHIB	1	
CPL Maylor	K1 RHIB	2	K2 RHIB after CAPT Bingley collected
CPL Irwin	K1 RHIB	3	
WO2 Rogers	K1 RHIB	4	
CAPT Grisinger	K1 RHIB	5	K2 RHIB after CAPT Bingley collected
TPR Irvine	K1 RHIB	6	
CAPT Bingley	K1 RHIB	7	
TPR Oliver	K2 RHIB	8	

Table 6. Likely order of collection of casualties from the water by K1 and K2 RHIB

154. All the casualties were transferred to HMAS KANIMBLA according to priority and opportunity. TPR Shephard was moved directly from the water to HMAS KANIMBLA via stokes litter. The order and timing are most likely as follows:

Rank/Name	Order recovered onto ship	Method	Time at medical	Elapsed time to medical	Location treated
CAPT Bingley	1	Stokes stretcher	1631	20mins	Resus 2
TPR Shephard	2	Stokes stretcher	1638	27 mins	Resus 3
TPR Oliver[16]	3(or 7)	171 Stretcher	Not recorded	29 (or >38) mins	High Dependency Unit (HDU)
CAPT Grisinger	4 (or 8)	Ladder	Not recorded	30 (or >38) mins	Canteen

16 Order and time of arrival of CAPT Grisinger, CPL Maylor and TPR Oliver at the medical facility was not recorded, therefore the elapsed time to medical for these personnel is an estimate.

CPL Maylor	5 (or 9)	Ladder	Not recorded	30 (or >38) mins	Canteen
TPR Irvine	6	Stokes stretcher	1643	32 mins	Resus 1
CPL Irwin	7	Strop	1645	34 mins	HDU
TPR Wilson	8	Strop	1646	35 mins	HDU
WO2 Rogers	9	Stokes stretcher	1649	38 mins	HDU

Table 7. Most likely order, timings and location of medical treatment

Post accident medical response

155. The PCRF had about 20 minutes to prepare to receive the casualties. CAPT Bingley was the first to arrive in the resuscitation area. Advanced life support principles were followed during the resuscitation effort including intubation, ventilation, CPR, intravenous emergency drugs, and defibrillation. Despite these efforts to revive him, CAPT Bingley was declared dead at 1651hrs.

156. The medical triage and treatment given to other casualties occurred simultaneously and effectively as they were received by HMAS KANIMBLA.

157. There was some confusion as to the specific requirements for dealing with aircraft accident aircrew in accordance with ADFP 731 Medical Guide to Aircraft Accidents / Incidents Investigation. There was not an aviation medical officer (AVMO) aboard HMAS KANIMBLA in support of 171 Avn Sqn. Once the PCRF was made aware of the requirements by one of the ship's medics, the collection of blood for toxicological analysis was completed.

158. Most post-accident aviation medicine duties were performed onboard HMAS NEWCASTLE by a senior AVMO once casualties were transferred there the next day.

159. The co-pilot remained on HMAS KANIMBLA and was allowed to return to flying duties by the aviation detachment commander prior to receiving medical clearance to fly, which is in contravention of SI (Avn) Ops 6-102 – *Medical Fitness for Flying*[xxxix] and SI (Avn) Ops 6-108 – *Post Mishap Flight Assessment*[xl]. This decision was made by the detachment commander as he believed it necessary in order to maintain operational capability. On the advice of the AAIT, the co-pilot was grounded until being assessed by the critical incident psychologist and AAIT AVMO. He was then cleared for flying by the OIC AAIT in consultation with the AAIT AVMO and subject to a check ride with a QFI.

SURVIVAL FACTOR ANALYSIS

160. **General.** The Black Hawk has a number of design features to reduce impact forces and protect the occupants in the event of an accident. Occupant survival is influenced by five

main factors: container, restraint, energy absorption, environment and post accident factors (CREEP). Each will be discussed.

161. **Container.** A container space ensures a survivable volume for the individual to occupy during the accident sequence. This area should remain free from structural and other intrusions to remain viable. Video of the initial impact suggests the container space was well maintained following impact with the ship, however, does not show the final aircraft condition after impact with the water.

162. **Restraints.** Restraints refer to the performance of the seat belts and harnesses. Witness statements indicated all on board were restrained in some manner when the aircraft accident occurred. The pilots and loadmasters were in their seats, wearing the standard four-point crew restraint systems. The loadmasters were likely to be leaning forward to perform the lookout function, and this may allow for more flailing than if sitting back in the seat. One of the loadmasters indicated he pushed back in his seat in preparation for the impact. The passengers were all attached to the floor by the use of single point strops, known as HRS. These were clipped to the wearer's belt, and appeared to have quick release attachments at both the person and aircraft end.

163. **Energy absorption.** The Black Hawk has design features to absorb vertical and horizontal impact forces. These features include the landing gear, seat design and structural members. Helmets will also allow energy absorption. Without analysis of the wreckage, the AAIT was unable to investigate which, if any, aircraft energy attenuation features were factors in the accident. The aircrew's helmets sustained some minor damage indicating impact with other objects during the accident sequence. One passenger had a waiver to not wear a helmet to allow use of communications equipment. Although it is accepted that a fitted aircrew helmet provides the best protection, the passenger helmets worn were IAW SI(AVN) OPS 3-201 *Carriage of Passengers*, and SFI 15/2006 *Passenger Helmet Matrix.*

164. **Environment.** The environment component of survival refers to the presence of objects within the aircraft environment, which are likely to cause injury during an accident. Witness statements indicate there were several unsecured items in the back of BLACK ONE that could have caused injury during the accident sequence. These included eight ammunition boxes, four Steyr rifles, and two Mag 58 barrels. In addition, passenger flailing during the accident sequence could have caused injury to themselves or other personnel.

165. **Post-accident factors.** Post-accident factors include issues such as disorientation and inability to find an exit whilst underwater, difficulty with egress from the wreckage, use of HABD, flotation of the wreckage, and survival once clear of the wreckage. Some or all of these factors may have been present during this accident.

Aircraft flotation

166. Witnesses reported that the aircraft sank very quickly. With both rear doors open and the loss of the tail section, it was unlikely that there would be any significant air pockets in the remaining fuselage that could have reduced the sink rate. The Black Hawk is not fitted with automatic flotation devices such as those on the Seahawk. If fitted, these may have reduced the sink rate or enabled the accident aircraft to remain on or just below the water's surface, providing the crew and passengers more time to egress and less distance to swim to

the surface. Given that there were divers in the water within a minute of the accident, and had the aircraft not sunk immediately, assistance could have been provided to an incapacitated, entangled, or disoriented occupant.

Decreased survivability

167. Given the evidence from witness statements and photos, it is likely CAPT Bingley was able to access his HABD regulator, egress the helicopter and activate both buoyancy chambers of his LPSV, however, the sequence that this occurred could not be ascertained. He probably had some difficulty with egress given that his helmet had been removed, he had lost his HABD bottle and regulator, and was believed to have been the last to surface. Although the LPSV was fully inflated and floating on the surface, CAPT Bingley's head remained below the waterline. His LPSV appeared to be void of an occupant due its high position on his body, and the absence of a helmet.

168. TPR Porter was not recovered. The AAIT was not able to determine his fate.

MEDICAL ANALYSIS

169. Medical analysis will be published in annex E as a separate medical-in-confidence report.[17]

HUMAN FACTORS ANALYSIS

Fatigue

170. **General**. The level of fatigue for an individual is due to a combination of three main factors; time awake and/or on duty, the amount of sleep debt, and the time of day (circadian rhythm).

171. **Work schedule.** The flying schedule was considered not to be demanding. The crew had three days without flying, followed by two days of scheduled afternoon/evening flying, the accident occurring on the second day of flying. The accident flight was the first planned sortie for the day, and occurred was only 15 minutes into the flight. The captain's usual routine was to arise at 0800 for breakfast and start work at 1030, therefore he would have been awake for eight hours at the time of the accident. The co-pilot had returned to sleep following breakfast, thus reducing time awake to only four hours.

172. **Sleep.** The surviving crew indicated they had ample sleep leading up to the accident sortie, in excess of ten hours per day and no apparent sleep debt. The captain's usual routine was to achieve nine hours sleep per day. The ship's embarked forces accommodation was not ideal for crew rest requirements. The aircrew accommodation consisted of crowded cabins with four high bunk beds and curtains, and sparse furniture. There was limited personal space and potential for interrupted sleep due to lights on times and wake up calls. The "white noise" environment of the ship may have masked some of the potential sleep disturbing noise associated with multiple personnel sharing a room.

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17 The AAIT medical-in-confidence annex E of the report is held by AAIT AVMO and is released to the relevant medical authority under ADFP 731. The findings are reviewed by medical specialists and advice is provided to subsequent inquiries as required.

173. **Circadian rhythm.** As the crew had been on board the ship for 30 days and operating a similar shift of afternoon/night flying for the previous flying days, their work/rest cycle was well established. It is likely that any circadian dysrythmia effects associated with changing shifts was not a factor. The AAIT considered that at the time of the accident the crew were at an acceptable level of alertness.

174. **Aircrew and aircraft captain fatigue.** Employing the ADF Crew Duty and Rest Planner,[18] the fatigue levels for the aircrew were calculated using 72 hour histories and work schedules. The AAIT determined that the crew fatigue levels were assessed as standard, with the exception of the aircraft captain who had a moderate level of fatigue. These results, according to the planner, were within acceptable fatigue levels for aviation duties. The aircraft captain had stated that "he was feeling slightly fatigued despite the amount of sleep he was getting," however, the captain assessed himself as fit to fly.[xli] Additionally, he was recorded on video napping immediately prior to the flight.[xlii] The AAIT could not determine what, if any affect it may have had on the aircraft captain's performance.

Situational awareness

175. **Background.** Situational awareness (SA) can be defined as "the perception of elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the future" (Endsley, 1988). An important part of an operating crews SA is to ensure that the crew's perception of the aircraft's operating environment is accurate. It is possible for a crew to have a perception of the aircraft and its operating environment which is in error. Perception errors may be subtle and a number of errors can combine to reduce the crews SA to a point where they can be unaware that a degradation in SA has occurred. More importantly, the crew may be unaware that these subtle perception errors may have eroded the safety margins normally associated with the operation of the aircraft.

176. **Visual cues – assessment of closing speed.** The flare and quickstop manoeuvre is essentially a visual procedure with back up from the GPS navigation system for guidance. The CCTV evidence shows that the accident aircraft was at a higher airspeed than expected in the later stages of the approach (groundspeed at 80 knots within 125m of the objective). It is therefore possible that the aircraft captain commenced the flare later than would normally be expected or alternatively, the flare may have been developed at a slower rate. Under these circumstances, the approach would have required a relatively high nose attitude flare to arrest the aircraft's closing speed to the objective; this would have restricted the available visual cues to the crew for assessment of objective closing speed and altitude. The visual assessment of groundspeed and closing speed at low-level over water can be difficult due to the relative lack of surface detail available. Additionally, the accident flight approach was the first approach flown from the bow of the ship, therefore the visual cues for distance to run would be different from those visible during previous approaches. These factors could have combined to minimise visual cues during the final run-in and flare phase of the approach. The lack of positive visual cues during this phase of the approach may have affected the crew's

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18 The ADF Crew Duty and Rest Planner was designed by the University of South Australia sleep research centre for use by ADF aircrew. Fatigue levels are rated in ascending order as standard, moderate, high, very high and extreme.

SA and limited the pilot and crew's perception that the aircraft was faster than expected or decelerating later than normal.

Finding. The lack of positive visual cues during the final run in and flare may have affected the crew's SA and limited the pilot and crew's perception that the aircraft was faster than expected or decelerating later than normal.

177. **Visual cues – assessment of altitude and ROD.** Due to the close proximity of the ship, the turn would have required a relatively high angle of bank (AOB) to the left. Additionally, more aft cyclic is required to maintain the aircraft level as the aircraft decelerates. Finally, the accident aircraft was turning into a downwind position at the end of the manoeuvre, again requiring aft cyclic control input to arrest residual forward speed. It is therefore possible that the aircraft had an increase in aft cyclic input prior to the pilot rolling over to level the aircraft at the end of the manoeuvre. From this point (with a high nose attitude and relatively close to the ship) judgement of both altitude and ROD would be difficult due to the limited lateral peripheral cues available to the pilot. It is therefore possible that if any ROD had developed late in the manoeuvre the pilot may not have become aware of it until attempting to level the aircraft. At this point, as the nose attitude is lowered, the pilot would have increased forward visibility and peripheral cues to assess height and ROD. Confirmation that other crew members became aware of the ROD and decreasing aircraft altitude was when the right side loadmaster made two warning calls in the final seconds prior to impact.

Finding. It is possible that if any ROD had developed late in the manoeuvre the pilot may not have become aware of it until attempting to level the aircraft.

178. **Attentional Focus.** Witness interviews indicated that the accident aircraft's approach appeared faster than the GOLD formation. Additionally, they observed the aircraft fly its approach relatively close in to the side of the ship (at one and a half rotor spans, from analysis of the ship's CCTV recording) along with an observation that the aircraft yawed further left during the turning quick-stop manoeuvre. Interviews with aircrew indicated that the aircraft captain may have been dissatisfied with some aspects of his flying accuracy prior to the accident flight. This related to ship underway recovery assaults. In particular, on the previous night sortie, the aircraft captain found that he was terminating in the hover somewhat short of the objective. It would therefore be quite normal for the aircraft captain to utilise the practice approaches to refine his approach accuracy during the mission. This may explain why the accident aircraft was observed to fly relatively close to the ship during its run in. For the same reasons, it is reasonable to assume that the further left yaw during the flare was the result of the aircraft captain's control input to ensure that he continued to visually track the objective (flight deck) as the aircraft had now passed the ship's superstructure and the objective was in view.

179. **Aircrew perception of ship's position.** Evidence suggests that the ship may have drifted away from the position logged by the crew at take off (the ship would be expected to drift due to a combination of sea current and wind). For an approach to a ship underway the crew would normally take the ship's changing position into account by programming the GPS navigation system with a "moving waypoint". For the accident flight, evidence suggests that the ship may have drifted laterally from BLACK ONE's take off position prior to the final

approach. Any lateral drift or drift toward the run in point (unless accounted for) would result in the GPS deceleration markers used by the crew being in error and closer in than the crew would expect. Evidence suggests that the datum for the ship's position during BLACK ONE's final run-in and flare was the position logged on the GPS navigation system at the time of take off. If the crew was unaware that the ship had moved away from the original position logged, this would erode the crew's SA and lead them to use GPS based deceleration markers which were actually in error.

> **Finding.** The ship drifted away from the original waypoint as logged into the GPS navigation system. This eroded the crew's SA and led them to refer to GPS based deceleration markers which were actually in error.

180. **Pilot's mental model.** On completion of the flaring turn, the final approach to the hover was under tail-wind conditions, where under previous practise scenarios the wind would have been a lateral wind or wind from ahead of the aircraft. At the end of the flare approach, the aircraft captain would normally be expected to pivot the aircraft around the tail-wheel and adopt a level attitude prior to moving across the deck. In the case of the accident flight, the tail-wind component would have required an aft cyclic input at the end of the flare to maintain the hover as compared to approaches to a ship underway. Additionally, without any headwind component, the power requirement (and therefore collective input) to achieve the hover would be greater. The predictive nature of SA often relies on a crew's "mental model" of prior experience. It is possible that the pilot's mental model of the power and control margins expected at termination was the same as for his previous practice approaches to a ship underway. The AAIT could not determine what the aircraft captain briefed with respect to the termination with a tailwind. The AAIT also could not determine to what extent the aircraft captain had pre-briefed or mentally prepared for the extra control and power requirements to level the aircraft and arrest the aircraft's forward movement (and any residual down vector) at the end of the turning flare manoeuvre.

> **Finding.** It is possible that the pilot's mental model of the power and control margins expected at termination was the same as for his previous practise approaches to a ship underway.

181. **SA Summary.** Due to a combination of factors - including inaccurate waypoint deceleration datum (ship's drift), limited visual cues, the pilot's mental model of the evolution and possible focused attention - it is likely that the crew assessed the approach as normal (for an SO approach as described at paragraph 95) up to the point where the aircraft had completed the flaring turn and began its unintended descent to the impact point. This is reinforced by aircrew witness statements which indicated that the approach looked normal up to the point where the aircraft commenced the final descent across the deck to impact, and that the pilot did not verbalise any concerns with the approach to this point.

> **Finding.** It is likely that the crew assessed the approach as normal (for an SO approach as described at paragraph 95) up to the point where the aircraft had completed the flaring turn and began its unintended descent to the impact point.

Human performance limitations

182. **Crew reaction time.** The AAIT determined that the pilot and other aircrew members of the accident flight did not perceive that the approach (although flown close in to the ship and relatively fast) was anything other than normal up to the point where the aircraft commenced the unintended descent over the deck to impact. The co-pilot indicated that the aircraft was at 95 ft above sea level as it passed abeam FLYCO,[19] it descended in the flaring turn and completed the manoeuvre at an altitude of 70 ft to 80 ft. From this point the co-pilot reported that the aircraft continued a relatively constant descent to the impact point. As the flight deck is 22 ft above sea level the co-pilot's evidence suggests that the aircraft may have commenced its final descent to the impact point from an altitude of between 48 ft and 58 ft above the deck. Analysis of the CCTV footage indicated that the aircraft impacted the deck at a rate of descent of 1300 fpm. Assuming that this rate of descent was constant from an altitude of 58 ft (above the deck) the aircraft would have impacted the deck approximately three seconds after completing the turning flare manoeuvre. If the pilot did not perceive a problem with the approach up to the point where the aircraft completed the flaring-turn manoeuvre, the remaining time and altitude available, given human performance limitations (reaction time), was insufficient to effect a recovery or go-round prior to impact.

> **Finding.** The pilot did not perceive a problem with the approach up to the point where the aircraft completed the flaring-turn manoeuvre.

Crew resource management (CRM)

183. **Policy.** DI(G) OPS 40-2 defines CRM as "the utilisation of all available resources by an individual or crew toward the goal of safe, efficient and effective operations". CRM is a management tool available to all members of the crew and operating team, the application of CRM principles is aimed at improving crew and mission performance and minimising errors.

184. **ADF CRM training**. IAW DI(G) OPS 40-2, CRM principles and practices are to be employed by Defence personnel operating ADF State aircraft. Members are considered CRM-current if they have completed training to the 'Skilled' level (i.e. following successful completion of operational conversions/type refreshers or ongoing re-currency training). CRM bridging training uses a standardised program to bring personnel up to a common level of CRM knowledge and expertise. Bridging training to the 'Trained' level is normally provided to all personnel who have not previously completed an ADF-recognised CRM program. The AAIT was unable to find any record of the co-pilot having conducted CRM bridging training, nor ongoing CRM re-currency training.

185. **Co-pilot CRM.** The crew had been crewed together for a number of flights previously. The co-pilot was relatively new to this type of operation. The captain was a highly experienced pilot and the unit QFI, and regarded by his peers as "an excellent pilot" – "a perfectionist." Under these circumstances the captain/co-pilot authority gradient could be described as steep. A steep authority gradient can induce a crew environment where the junior or less experienced members of the crew may be unwilling to voice concerns with aspects of

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19 The FLYCO station is an observation and helicopter control station located ahead and to the port side of flight deck. It is approximately some 20 ft above the height of the flight deck and typically 42 ft above sea level.

the flight, and may tend to defer to the more experienced and more senior personnel. Although the co-pilot had not conducted CRM training, there was no evidence to suggest that the co-pilot (or any other member of the crew) would not have raised safety concerns if they had perceived any. The co-pilot had no recent exposure to an approach from ahead of the ship. It is probable that the co-pilot was not aware of anything untoward with the approach up until the final unintended descent just prior to impact. Under these circumstances he would not necessarily communicate any concerns with the approach as he perceived the approach as normal. The co-pilot did not report any communications from the aircraft captain regarding any concerns with the approach. Both loadmasters reported that the approach appeared to be normal until just prior to crossing the deck. Under these circumstances it is difficult to determine what effect, if any, co-pilot CRM training may have had on the in-flight development of the accident sequence.

186. **Loadmaster CRM.** Both loadmasters on the accident flight indicated that they thought the approach was normal up until the aircraft had completed its turn and was moving toward the deck. Neither loadmaster had recent experience of an approach from ahead of the ship as conducted on the accident flight. Apart from flying in from the ship's stern, which gives an unobstructed view of the objective, the approaches practised previously were flown to a ship underway and therefore into a relative headwind component. Given the limited previous exposure to an approach from ahead of the ship, the loadmasters would have had limited visual cues to warn them if the approach was too fast or if the deceleration point had been left too late. It is likely that neither of the loadmasters were aware of anything untoward with the approach up until they realised that the height was low and ROD too high just prior to impact. At this point the right side loadmaster verbalised his concerns with the aircraft's height and ROD prior to impact by calling "maintain height" and as the aircraft continued to descend called "come up – come up". The left side loadmaster also realised that the aircraft was too low and descending after completing the left turn toward the objective. He was aware that the right loadmaster was concerned about the aircraft's height and ROD as he also heard the right side loadmaster give height warnings. The left side loadmaster thought that the aircraft's rotor rpm had decreased and, as the right side loadmaster had already made the required calls to advise the aircraft captain of his height and ROD, he decided that this was sufficient and the aircraft captain was doing his best to arrest the ROD. He decided not to make any further calls until the RPMR had recovered. (Note: witnesses reported that it is not uncommon for RPMR droop or a temporary decrease in RPMR to occur at the end of the flare as the aircraft adopts the hover attitude). Given the limited time available between the aircraft completing its left turn toward the objective at the end of the approach and the unexpected descent and subsequent impact, it is assessed that both loadmasters used good in-flight CRM techniques and the right side loadmaster verbalised adequate height and ROD warning calls to the aircraft captain prior to impact.

187. **Inter-crew CRM.** There is evidence to suggest that the crews of GOLD ONE and TWO had re-checked the position of the ship's deck (the objective) prior to flying their approach. During this process the crews of GOLD ONE and TWO discovered that the objective had drifted away from the original datum position at take off. GOLD subsequently re-entered the position for the objective and used this for their approach. There is no evidence to suggest that this information was passed to BLACK. The procedure used by crews when the GPS navigation information does not agree with the visual assessment of range to the objective is to default to a visual assessment using the GPS information as a guide only.

Whilst the ship is underway, crews would normally take the ship's changing position into account by entering a "moving waypoint" into the GPS system. Although GOLD ONE discovered that the ship had moved from the initial datum, it is possible that the crew of GOLD ONE did not realise the effect the changed position could have on the GPS based deceleration profile. If the crew of GOLD ONE were aware of the effect that small changes in GPS datum position would have on the deceleration profile, it is reasonable to assume that the crew of GOLD ONE would believe that the crew of BLACK formation would default to a visual assessment. Due to these factors, the crew of GOLD ONE may not have perceived this information as "relevant" for BLACK. CRM is a "whole of operation" concept and not simply an internal crew management tool. Although not considered a major factor, the information on the changed objective position, if passed to all crews involved in the operation, could have added to both BLACK and GOLD's SA during the mission.

Organisational culture – norms and rules

188. **171 Avn Sqn operations and the application of AVRM.** 171 Avn Sqn operations are (understandably) often conducted at or near the limits of both aircraft and crews. Under these circumstances it is possible for the culture within the unit or for individuals within the unit to become desensitised to the risk associated with perceived normal operations. Although, in the time available, the AAIT was unable to conduct a full assessment of the risk and safety culture within 171 Avn Sqn, the AAIT reviewed the deeper-level risk management plans for the deployment and operation and assessed these as comprehensive and well prepared. The AAIT was unable to ascertain what AVRM processes were conducted at the operational/tactical level by the flying crews and/or flying supervisors for this particular flight profile (first approach from the bow versus the stern, first approach to a stationary (drifting) objective versus ship underway and tailwind versus headwind hover termination).

189. **AVRM at the tactical level.** A detailed application of the AVRM process, at the tactical level, is designed to address and or mitigate as many of the risks and conditions that the flight crews would encounter during the mission. The AAIT believes that a thorough application of the AVRM process at the tactical level should have identified the risks that the flight crew were likely to encounter during the mission execution, such as:

a. 'ship's drift',

b. termination to the hover with a downwind component,

c. power and control requirements,

d. approaches to 'static' objective versus a ship underway,

e. currency and recency in the conduct of approaches to a 'static' objective,

f. personal mission equipment requirements, and

g. carriage of passengers.

190. From inspection of documentation, the AAIT could not ascertain what AVRM processes were applied specifically to this SO assault serial.

Finding. The AAIT could not ascertain what AVRM processes were applied specifically to this SO assault serial. A thorough application of the AVRM process at the tactical level should have identified the risks that the flight crew were likely to encounter during the mission execution.

191. **Acceptance of main rotor rpm droop.** Pilots interviewed reported previous occurrences of main rotor rpm droop during practise approaches similar to those being conducted on the accident flight. One pilot reported that RPMR droop to 90% had been experienced during the SO assault manoeuvre. Aircrew indicated that main rotor rpm droop occurred sufficiently often that it is routinely accepted and regarded as a consequence of the manoeuvre. In all previous cases of RPMR droop (even down to 90%) the aircraft was observed to recover RPMR without it entering a range where main rotor rpm had become irrecoverable in the time/altitude available.

Finding. Acceptance of RPMR droop, as a consequence of the SO assault manoeuvre, may indicate that the aircraft is being operated at or near its limits with reduced margins for safety.

SO assault techniques – safety margins.

192. The parameters applicable for a given embarked operation will normally be outlined in a SHOL, or the aircraft Flight Manual, Unit SI's and Unit SOP's. These parameters are designed to provide operators with adequate safety margins. When there is no published SHOL or when specific parameters are not stated, the provision of adequate safety margins for an operation may rely solely on the judgement of the aircraft operating crew.

193. There are a number of 5 Avn SOP which relate to SO procedures. The only procedural guidance for the assault manoeuvre identified by the AAIT was found in the "Special operations techniques briefings". This document gives a broad outline of the procedures and specific guidance on height and airspeed for the run-in and calculation of deceleration points for the flare etc.

194. The procedure, as detailed at paragraph 101 and 102, does not provide guidance to the crew on how to assess that a successful termination over the objective may (or may not) be guaranteed. The briefing gives guidance on the flare entry gate, however, does not provide any further guidance on the exit gate of the procedure, nor does it provide any mandatory go-round criteria. The briefing notes state: "*Energy, airspeed, height and RRPM, any two of the three will result in difficulties in termination. All three and it will be an interesting approach.*"

195. The briefing notes are operationally focused. The scope of the briefing includes the following points:

1. State the stages of an SO assault.

2. Describe the techniques for the termination.

3. Be aware of the crew duties.

> 4. *Know the standard calls and procedures for SO.*

196. The AAIT could not identify any go-round criteria or specific safety considerations in the SO techniques briefings provided.

197. The approach flown by the accident flight crew, although to a downwind termination, was otherwise in accordance with the description provided in the SO techniques briefing notes. As the flying evolution described requires continually changing aircraft attitude, altitude, airspeed, control input and power requirement, and is conducted at relatively low level (100ft) and *"as fast as possible"*, the potential for aircrew perceptual error is high. Additionally, as the last "*¾ of the deceleration in the termination is conducted in the last ¼ of the distance to run*"; the flying crew is left with very little time to accurately assess if the aircraft will be able to conduct a successful termination over the objective. The AAIT believes that the procedure as described in the briefing notes leaves very little margin for error. If, as in the case of the accident flight, the procedure incorporates a comparatively fast approach into a relatively tight turning quickstop, terminating with a downwind component to the objective, it may not be possible for a crew flying the approach in accordance with the parameters described in the briefing notes, to accurately assess the capability for a successful termination until it is too late to recover the aircraft or conduct a successful go-round.

> **Finding.** The AAIT believes that the procedures described in the SO techniques briefing notes provide minimal safety margins. It may not be possible for a crew flying the approach, in accordance with the parameters described in the briefing notes, to accurately assess the capability for a successful termination until it is too late to recover the aircraft or conduct a successful go-round. The AAIT could not identify any go-round criteria or specific safety considerations in the SO techniques briefing notes provided.

198. **Human factors summary.** The acceptance of levels of risk for training and operations relies heavily on command (and crew) judgement and the context of the mission. For this very reason, 171 Avn Sqn operations are often conducted at or near the limits of both aircraft and crew. The SO mission requires detailed planning, high levels of crew skills, CRM, judgement, SA, aircraft performance and risk management. When a task requires the crew or aircraft to operate at or near their limits, as is with the SO assault, even a minor degradation of any one of these elements can have a negative impact on the safe execution of the mission.

> **Finding.** The SO mission requires detailed planning, high levels of crew skills, CRM, judgement, SA, aircraft performance and risk management. Even a minor degradation in any one of these elements can have a negative impact on the safe execution of the mission.

OVERALL CONCLUSION

199. The AAIT's terms of reference required the team to identify the sequence of events and ascertain those factors (hazards) which directly and/or indirectly led to the accident. As well, the team investigated aircrew and passenger survivability and analysed some aspects of the effectiveness of the emergency response. In this report, as much factual information as available was analysed to inform decision makers of the circumstances surrounding the

accident and to ensure safety recommendations are implemented in order to preserve capability.

200. In this investigation a number of elements were examined including organisational and latent failures, local and human factors, and inadequate or absent defences, to identify contributing factors.

Summary of findings

201. The AAIT preliminary findings are as follows:

a. There were deficiencies in some of the personal LSE worn by aircrew and the SO personnel on the flight (para 32 – 36 and table 4).

b. Not all SO personnel had completed HUET. Furthermore the training, except for qualified divers, only includes but not practical training on the EBA. (para 37 – 39).

c. One aircrew member had not completed CRM training (para 65).

d. The TMP for the SO course is not finalised (para 91).

e. The SO assaults, as carried out by 171 Avn Sqn, may place the aircraft in a flight regime where the flight manual 'WARNING' states that transient rpm droop may result (para 116 – 123).

f. From simulator trials, a combination of a late flare and deceleration, terminating into the hover with a tailwind, reduced lateral spacing from the objective and increased all up weight during the assault manoeuvre, affected the outcome (para 123 – 132).

g. On the balance of probability, the aircraft was serviceable at the time of the accident, vortex ring state was not a contributing factor, and rotor rpm droop occurred at the completion of the flare and turn (para 137 – 145).

h. The lack of positive visual cues during the final run in and flare may have affected the crew's SA and limited the pilot and crew's perception that the aircraft was faster than expected or decelerating later than normal (para 176).

i. It is possible that if any ROD had developed late in the manoeuvre the pilot may not have become aware of it until attempting to level the aircraft (para 177).

j. The ship drifted away from the original waypoint as logged into the GPS navigation system. This eroded the crew's SA and led them to refer to GPS based deceleration markers which were actually in error (para 179).

k. It is possible that the pilot's mental model of the power and control margins expected at termination was the same as for his previous practise approaches to a ship underway (para 180).

l. It is likely that the crew assessed the approach as normal (for an SO approach as described at paragraph 95) up to the point where the aircraft had completed the flaring turn and began its unintended descent to the impact point. The remaining time and altitude available, was insufficient to effect a recovery or go-round prior to impact (para 181 and 182).

m. The AAIT could not ascertain what AVRM processes were applied specifically to this SO assault serial. A thorough application of the AVRM process at the tactical level should have identified the risks that the flight crew were likely to encounter during the mission execution. (para 189).

n. Acceptance of RPMR droop, as a consequence of the SO assault manoeuvre, may indicate that the aircraft is being operated at or near its limits with reduced margins for safety (para 191).

o. The AAIT believes that the procedures described in the SO techniques briefing notes provide minimal safety margins. It may not be possible for a crew flying the approach, in accordance with the parameters described in the briefing notes, to accurately assess the capability for a successful termination until it is too late to recover the aircraft or conduct a successful go-round. The could not identify any go-round criteria or specific safety considerations in the SO techniques briefing notes provided. (para 192 to 197).

p. The SO mission requires detailed planning, high levels of crew skills, CRM, judgement, SA, aircraft performance and risk management. Even a minor degradation in any one of these elements can have a negative impact on the safe execution of the mission (para 198).

Safety recommendations

202. The AAIT make the following safety recommendations:

a. COMD 16 Bde (Avn):

(1) review the SO assault technique and guidance material to:

(a) ensure that operations to a 'ship not making way', other than those to a ship at anchor, incorporate an accurate assessment of likely ship's drift and that this is incorporated in mission planning and execution;

(b) ensure that procedures and techniques are within the capabilities of the aircraft systems on which they are based (e.g. main rotor rpm droop); and

(c) ensure procedures detail parameters that provide adequate safety margins (e.g., minimum rotor spacing, go-round criteria etc);

(2) review and reinforce the application of the AVRM process at the tactical level, to ensure that it is being used to adequately identify, assess, and mitigate risks;

(3) finalise the TMP for the SO course, incorporating the reviewed procedures;

(4) ensure the deficiencies identified with the LSE and role equipment used for over water operations are rectified;

(5) ensure that aircrew are current and trained in CRM IAW DI(G) OPS 40-4; and

(6) ensure aircrew are briefed on the implications of the findings and safety recommendations.

b. COMD SO ensure:

(1) SO personnel involved in over water operations are adequately trained in HUET and EBA, and

(2) ensure the deficiencies identified with the LSE and role equipment used for over water operations are rectified.

P.F.J. BLAIS
WGCDR
OIC AAIT

16 Feb 07

ANNEX A TO
AAIT REPORT
16 FEB 07

LIST OF ACRONYMS

Acronym	Definition
5 Avn Regt	5th Aviation Regiment
AAIT	Aircraft Accident Investigation Team
ADF	Australian Defence Force
ADFHS	ADF Helicopter School
AFHRs	Aircraft Flying Hours
AFO	Army Flying Order
AGL	Above Ground Level
AHO	Above Highest Obstacle
AMSL	Above Mean Sea Level
ARFOR	Area Forecast
ASOR	Aviation Safety Occurrence Report
ATT	Aviation Team Training
AVMED	RAAF Institute of Aviation Medicine
AVMO	Aviation Medical Officer
AVRM	Aviation Risk Management
BoM	Bureau of Meteorology
CAPT	Captain
CFU	Carried Forward Unserviceability
CPI	Crash Position Indicator
CRM	Crew resource Management
CVR	Cockpit Voice Recorder
DAHRTS	Defence Aviation Hazard and Report Tracking System
DASM	Defence Aviation Safety Manual
DI	Defence Instruction
DRN	Defence Restricted Network
EBA	Emergency Breathing Apparatus
EE500	Maintenance Form Army Aircraft
ES	RAAF East Sale

Acronym	Definition
FDR	Flight Data Recorder
FF&MS	Full Flight And Mission Simulator
FIHA	Flight Information Handbook
FLTCDR	Flight Commander
ft	Feet
GPS	Global Positioning System
GR	Grid Reference
Hpa	Hectopascals
HQAAVNTC	Headquarters Army Aviation Training Centre
hrs	Hours
HRS	Helicopter Restraint Strop
IAW	In Accordance With
ICAO	International Civil Aviation Organisation
ICS	Internal Communications System
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
ITT	Inlet Turbine Temperature
KIAS	Knots Indicated Air Speed
KTS	Knots
LF	Low Flying
LP	Landing Point
LPSV	Low Profile Survival Vest
LT	Lieutenant
LZ	Landing zone
MO	Medical Officer
MRP	Mission Risk Profiles
m	Metres
Nm	Nautical Miles
NOE	Nap-of-Earth
NOTAM	Notice to Airmen
NVG	Night Vision Goggle
OAA	Operational Airworthiness Authority

Acronym	Definition
OA 82	Flight Authorisation Form
OC	Officer Commanding
OGE	Out-of-Ground Effect
OIC	Officer in charge
PCRF	Primary Casualty Reception Facility
QFI	Qualified Flying Instructor
QFI	Qualified Flying Instructor
RMO	Regimental Medical Officer
RMP	Risk Management Plan
RMP	Risk Management Plan
SA	Situational Awareness
SAA	School of Army Aviation
SFI	Special Flying Instruction
SHOL	Ship's Helicopter Operating limit
SI	Standing Instruction
SIGMET	Significant Metrological Conditions warning forecast
SOP	Standard Operating Procedure
SQN	Squadron
SRP	Standard Risk Profile
SSGT	Staff Sergeant
TAF	Terminal Area Forecast
TMP	Training Management Package
TOR	Terms of Reference
TTF	Trend Type Forecast
UFO	Unit Flying Orders
UTAP	Unit Training and Assessment Program
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

**ANNEX B TO
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GLOSSARY OF TERMS

Term	Definition
Deck Landing Practices (DLP)	Definition in ABR 5149
Airborne Fire Support line (AFSL)	Control Line used for the separation of Fire Support and Assault Aircraft
Landing Point (LP)	Specific insertion point nominated , methods of insertion include Airland, Hover dismount and Fast Roping
Landing Zone (LZ) –	An area that contains one or several LPs and is designated as a Landing Zone. A landing zone will be identified before an LP.
Finding	A concise statement of factors that contributed to the unsafe acts or conditions resulting in the incident/accident.
Flight Levels (F)	Flight levels indicate that the aircraft were flying at standard International Civil Aviation Organisation (ICAO) levels using an altimeter setting (QNH) of 1013 HPa.
Ft	Altitudes in ft represent height above mean sea level (AMSL) using area QNH.
PMKeys	Personnel management software used by the ADF to track personnel training and qualifications.
QNH	The pressure reference set to an aircraft's altimeter to ascertain height above either ground level using the pressure an area or mean sea level using the international standard pressure setting of 1013 Hpa
Recommendation	A proposal by the AIIT/AAIT to the Appointing Authority that, if implemented, could prevent or minimise the risk of a recurrence of the incident/accident.
SIGMET	SIGMETs are issued by the Australian Bureau of Meteorology when significant weather has occurred or is expected to occur in an area over which area meteorological watch is being maintained.

ANNEX C TO
AAIT REPORT
16 FEB 07

LIST OF WITNESS STATEMENTS RECEIVED BY AAIT

Rank	Name	Surname	ID No
CAPT	M.	Andrae	8225623
CPL	D.	Astbury	8264785
LCPL		Atkinson	8300011
TPR		Babich	8241916
CPL	David Robert	Baggett	8243885
ABSN	Melissa	Ball	8488316
SGT	P.J.	Bardanega	8217388
ABCIS1		Barklem	F8492136
CAPT	A.M.	Bell	8212553
CFN	Wilbur Paul	Brown	
LCPL	J.M.	Cahill	8436974
CPL	Mark	Calvert	8213164
CPL	Mark	Calvert	8213164
CAPT	Tony	Cameron	8263895
ABBA		Chun	8488365
CAPT	H.M.	Clancy	8253123
SBLT		Clarke	8487393
TPR		Cleggett	8499893
CPL	M.J.	Coll	8228989
MAJ	Tim	Connolly	8212737
SIG	Jason	Critch	8271681
CAPT	Michael	Cullen	8267557
CPL	B.K.	Davidson	8233766
CPL	P.R.	Douglass	8217852
CPL	M.D.	Doyle	8258751
LSWTR	Kylie	Emery	8120029
CFN		Evans	8264519
PTE	Anthony	Evans	8228111
CMDR	Hamish C.M.	Foster	C103036
TPR	Bernard	Galea	8499231
CPL	E.S.M.	Goh	8224116
CAPT	John C.	Grisinger	8221043
POCSS	Michael	Hales	8084798
PTE	Michael	Hammett	8491781
ABATA		Healey	8118614
CPL	D.A.	Hoare	8244323
LSBM	D.	Hofman	8099253
SGT	D.C.	Hogan	2802760
SMNCIS1		Holl	F8505804
ABET	A.L.	Inwood	8440878

Rank	Name	Surname	ID No
CPL	E.	James	8236390
LT	Chris	Jones	M8116493
CPL	Anthony	Kalzmarczyk	8261793
		Kennedy	8227358
LCPL	Aaron William	Kierath	8240276
LTCOL	M.J.	Kingsford	8268578
CFN	Trent Ian	Kingston	8229413
LSCSO	G.R.	Lambert	8118416
LCPL	Joseph	Laycock	8240356
CPL	Michael	Leadbitter	8270238
ABSN	Jaydee	Leonard	8439293
LSBM	Matthew George	Levi	8097633
TPR	Tim	Lowndes	8411359
LSCIS	Luke	Kasehagen	M8115686
LCPL	S.	Macey	8226424
CAPT	Helen	Mammino	8214738
CPL	Robert	Maylor	8238820
CFN	Patrick John	McCarthy	8235230
LSN		Mercer	8107951
CPL	Darren Trevor	Miller	8243568
TPR	A.R.	Mitchell	8261205
PTE	J.D.	Oliver	8270737
PTE	J.M.	Oliver	8245240
PTE	James David	Oliver	8270737
ABBM		Owen-Turner	
PTE	Lucas William	Petersen	8435584
WOMT	Peter Michael	Porter	M8070555
PTE	J.J.	Rathbone	8438587
WO2	D.D.	Rule	8257950
CAPT	M.A.	Salmon	553991
CPL	D.	Schmidt	8262495
CPL	S.P.	Scifleet	8260057
SMN	B.M.	Shirley	8505083
CFN	A.	Singh	8491807
CPL	D.E.	Smith	8265473
CAPT	James William	Sparks	8232110
LCPL	Rachel	Stonestreet	8253583
WO2	A.K.	Symes	8225927
SMN	C.D.	Trevethan	8499439
CFN	R.S.	Vagg	8251505
CPO	Scott	Wake	8091061
LCPL	Clay Richard	Watts	5803276
SIG	P.J.	Weaver	8500626
ABBM		White	8117067
CPL	S.A.	White	8255027

Rank	Name	Surname	ID No
CPL	J.A.	Wigan	8266495
AB	Patrick John	Williams	8258050
LCDR	Graeme	Wong	8033860

ANNEX D TO
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INVESTIGATION REFERENCES TO DATA COLLECTED

Note: The numbering of the reference material below has numerals (ii) and (xxiv) missing as a result of using Microsoft Word during production of the report. This was beyond the control and expertise of the AAIT to remedy.

i	Reg No 307 – Frago 43 to JTF OPORD 01/06 DTG 291305Z Nov 06
iii	Reg No 283 – MINDEF letter to Prime Minister dated 22 Dec 06
iv	Reg No 287 – Aircrew member summary status, Bingley M.A.
v	Reg No 028 – Flight Authorisation Book page 11 Ser No 87
vi	Reg No 019 – CD Camera 2 Disk 2 of 2
vii	Reg No 064 – CD Camera 3 disk 2 of 2
viii	Reg No 064 – CD Camera 3 disk 2 of 2
ix	Reg No 019 – CD Camera 2 Disk 2 of 2
x	Reg No 020 – Ship Officer of the Watch log
xi	Reg No 028 – Flight Authorisation Book page 11 Ser No 87
xii	Reg No 059 – Statement by 8300011 LCPL C.J. Atkinson
xiii	Reg No 081 – OP Quickstep – Request for Waiver – Minimum requirements for passenger helmets dated 09 Nov 06
xiv	Reg No 321 – Helicopter Restraint Strop brief for Chief Engineer GSSPO
xv	Reg No 019 – Camera 2 video – disc 2 of 2 video time 04:23:40 to 4:30:00
xvi	Reg No 310 – SFI 12/2003 - *Use of the Aircrew Safety Survival Equipment Ensemble* dated 12 Dec 05
xvii	Reg No 238 – AAIT SITREP DTG 021201Z DEC 06
xviii	Reg No 299 – E-mail Mr John Fox to WGCDR Blais dated 23 Dec 07 15:06
xix	Reg No 311 – E-mail Dakin to WGCDR Blais dated 24 Jan 07 10:10 *AAIT Request*
xx	Reg No 046 – Photograph on CD 20061129ran8106603_015
xxi	Reg No 279 – Email CAPT George to WGCDR Blais 17 Jan 07
xxii	Reg No 309 – E-mail Maj Nicholls to WGCDR Blais 24 Jan 07 08:34
xxiii	Reg No 321 – Helicopter Restraint Strop brief for Chief Engineer GSSPO
xxv	Reg No 283 – MINDEF letter to Prime Minister dated 22 Dec 06
xxvi	Reg No 235 – ADO service record – CAPT Mark Anthony Bingley
xxvii	Reg No 234 – ADO service record – CAPT John Campbell Grisinger
xxviii	Reg No 237 – ADO service record – WO2 Christopher David Rodgers
xxix	Reg No 236 – ADO service record – CPL Phillip Geoffery Irwin
xxx	Reg No 214 – Crew Resource Management waiver
xxxi	Reg No 030 – TAF/METAR Sheet
xxxii	Reg No 019 – CD Camera 2 Disk 2 of 2
xxxiii	Reg No 020 – Ship Officer of the Watch log
xxxiv	Reg No 077 – GPS mark of accident on reverse of Ship's Daily Brief
xxxv	Reg No 273 – TE 636.2.1.3 SITREP 023/06
xxxvi	Reg No 295 – SI (Avn) Ops 3-201
xxxvii	Reg No 242 – Computer printout of Black Hawk simulation

xxxviii	Reg No 297 – E-mail Simpkin/Pearson dated 18 Jan 07
xxxix	Reg No 311 – SI Avn Ops 6-102 – Medical Fitness for Flying
xl	Reg No 312 – SI Avn Ops 6-108 – Post Mishap Flight Assessment
xli	Reg No 316 – E-mail from Cullen CAPT Bingley 72 hour History
xlii	Reg No 233 – Recovered image from DV Tape from BLACK ONE