Ministry of Defence

Air Command Secretariat
Spitfire Block
Headquarters Air Command
Royal Air Force
High Wycombe
Buckinghamshire
HP14 4UE

Ref: 2017/05636

[redacted]

27 June 2017

Dear [redacted]

Thank you for your email of 27 May 2017 requesting the following information:

'FOI request for the Board of Inquiry report into loss of tornado GR4 ZG711 on 24 Oct 2006.

I am requesting that the above report is released as I am writing about the incident for a book I am publishing on aircrew decision making.

[redacted]

I am treating your correspondence as a request for information under the Freedom of Information Act 2000 (FOIA).

A search for the information requested has now been completed within the Ministry of Defence (MOD), and I can confirm that information in scope of your request is held. Please see attached the Board of Inquiry (BOI) report into the Tornado GR4 ZG711 accident on 24 Oct 2006.

Under section 40 of the FOI Act, any personal data within the BOI has been redacted and is exempt from disclosure. It would be unfair and unlawful to disclose this type of information without consent and it would breach the fair processing principles of the Data Protection Act. Section 40 is an absolute exemption and not subject to public interest testing.

Under section 43 of the FOI Act, details of the sum paid to DG Scales Plant Hire Limited for ground restoration work has been redacted from the BOI and is exempt from release. The balance of the public interest test concluded that whilst release would provide financial transparency to the public, it would prejudice the commercial interests of organisations and the commercial relationships they have with other organisations. The balance of the public interest therefore lay in withholding this information.

You may wish to note that the MOD Defence Instructions and Notices (DIN) 03-029 sets out the arranagements that all MOD personnel must follow if they wish to write or speak publicly on Defence or Government matters. Paragraph 13 outlines that 'For communication on non contentious subjects ,personnel below 1* and civilian equivalents must seek the permission of their Commanding Officer or Head of department or Division, and consult local Top Level Budget /Arm's Length Bodies or Service media staff'. Therefore, should you wish to publish a book, on aircrew decision making, it is advised that you seek approval from your Chain of Command.

Turning to using the details found in the BOI within the book, you may wish to know that all wording, plus all illustrations (such as photographs), created by Crown Servants (including military and MAA) are Crown Copyright. These may be freely reproduced, subject to acknowledgement as being Crown Copyright used under licence (and some very minor other restrictions), in accordance with the Open Government Licence which can be found here:

http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/.

The MOD are unable to authorise the reproduction of any non-Crown Copyright material: in such cases permission should be sort from the copyright owner.

If you are not satisfied with this response or wish to complain about any aspect of the handling of your request, then you should contact me in the first instance. If informal resolution is not possible and you are still dissatisfied then you may apply for an independent internal review by contacting the Information Rights Compliance Team, Ground Floor, MOD Main Building, Whitehall, SW1A 2HB (e-mail CIO-FOI-IR@mod.uk). Please note that any request for an internal review must be made within 40 working days of the date on which the attempt to reach informal resolution has come to an end.

If you remain dissatisfied following an internal review, you may take your complaint to the Information Commissioner under the provisions of Section 50 of the Freedom of Information Act. Please note that the Information Commissioner will not investigate your case until the MOD internal review process has been completed. Further details of the role and powers of the Information Commissioner can be found on the Commissioner's website: http://www.ico.org.uk.

Yours sincerely,

[redacted]

Air Director Resources Secretariat
Air Command

[redacted]

RAF Form 412A
(Revised 2/97)

Copy No. 9 of 9

ROYAL AIR FORCE

BOARD OF INQUIRY/UNIT INQUIRY

INTO AN

AIRCRAFT ACCIDENT OR INCIDENT

GENERAL DETAILS OF THE ACCIDENT OR INCIDENT

DATE	24 OCT 06	LOCATION AND GRID REFERENCE	HOLBEACH	
AIRCRAFT TYPE(S)		MARK(S)	SERIAL NUMBER(S)	PARENT UNIT(S)
TORNADO		GR4A	ZG 711	MARHAM
NAME(S) OF PILOT(S)		Sqn Ldr [redacted]	PARENT UNIT(S)	MARHAM
		Flt Lt [redacted]		MARHAM

NUMBER OF CASUALTIES					
KILLED			INJURED		
CREW	PASSENGERS	OTHERS	CREW	PASSENGERS	OTHERS
–	–	–	2	–	–

[redacted]

[redacted]

RAF FROM 412 (ADP)
(Revised 2/97)

PART 1:

DETAILS OF THE BOARD

[redacted]

[redacted]

RAF FORM 412 (ADP)
(Revised 2/97)

ROYAL AIR FORCE
PROCEEDINGS OF A BOARD OF INQUIRY
INTO AN AIRCRAFT ACCIDENT

PART 1

DETAILS OF THE BOARD

Assembled on 25 Oct 06 at RAF Lossiemouth

By order of the Air Officer Commanding 1 Group

To inquire into an accident involving Tornado GR4A ZG711 on 24 Oct 06

Reconstituted with a new president on 6 Feb 07

1. Composition of the Board.

Duty	Rank, Name, Service No & Decoration	Branch	Unit
President	Sqn Ldr [redacted]	Fg(P)	RAF Lossiemouth
	Vice Sqn [redacted]	Fg(P)	RAF Lossiemouth
Members	Flt Lt [redacted]	Fg(P)	RAF Lossiemouth
	Flt Lt [redacted]	Eng	RAF Lossiemouth

2. Full Terms of Reference.

a. Investigate the circumstances of the accident to Tornado GR4A ZG711 at Holbeach AWR on 24 Oct 06.

b. Determine the cause or causes of the accident and examine related factors.

c. Ascertain the degree of injury suffered by persons both Service and civilian.

d. Ascertain if Service personnel involved were on duty.

e. Ascertain if all relevant orders and instructions were complied with.

f. Ascertain if aircrew escape and survival facilities were fully utilised and functioned correctly.

[redacted]

[redacted]

g. Ascertain extent of damage to the aircraft, public property and civilian property.

h. Assess any human factors.

i. Make appropriate recommendations.

j. Investigate the loss of any classified information.

3. The Board is to consider whether Human Factors affected the cause of the accident but should not consider, nor make any statement about blameworthiness. Notwithstanding that human failings are not to be assessed, individuals whose professional reputation maybe affected by The Board of Inquiry findings are still to be afforded the protection of QR1269.

4. The Board is to be conducted and progressed in accordance with QR(RAF) Chap 17 and APP 35, as amplified by JSP 551 section 205 Annex C, and is to be completed on RAF F412. QR 1272 should be consulted.

5. The attention of The Board is particularly drawn to the following paras of JSP 552 Section 205 and Section 205 Annex C:

a. Submission of Interim Report.

b. Submission of Special Interim Finding.

c. Progression of The Board.

d. Immediate reporting of hazards.

e. Fatal Accident Reports if applicable.

[redacted]

RAF FROM 412 (ADP)
(Revised 2/97)

PART 2:

CONCLUSIONS OF THE BOARD

[redacted] Sqn Ldr
President BOI

[redacted]

CONCLUSIONS OF THE BOARD

PART 2

NARRATIVE OF EVENTS

(All times LOCAL)

1. Introduction. On 24 Oct 06 the crew of ZG711, callsign Spartan 1, was tasked to lead a pair of aircraft (ac) on a Close Air Support Exercise (CAS Ex), preceded by a range weaponeering detail in the Wash Air Weapons Ranges (AWRs). On approach to Holbeach AWR, flying at 380ft Radar Altimeter (Rad Alt) and 430kts KCAS, the ac flew through a large flock of birds and sustained multiple birdstrikes. Both engines experienced a marked loss of thrust; the pilot climbed to 2410ft Rad Alt and turned north towards the Wash. Attempts were made to restart the engines but without success. The ac began to descend towards the sea and the underwing fuel tanks were jettisoned. The ac continued to descend, the crew ejected and the ac crashed into the Wash mud flats. The crew was rescued by two RAF Search and Rescue (SAR) Sea King helicopters and flown to hospital in King's Lynn. Witnesses 1/2, Exhibit 1, Exhibit 2, Annex D

2. Pilot's Background. At the time of the accident, Sqn Ldr [redacted] was a non-Combat Ready Pilot, a Qualified Flying Instructor and Qualified Weapons Instructor on 31 Sqn who was four weeks into his flight commander tour. His previous tour had been at the Defence Aviation Safety Centre (DASC), RAF Bentley Priory. He had a total of 2138 flying hours, of which 919 hours were on the Tornado GR1/4, and his last flying assessment, dated 31 Mar 04 whilst flying on 19(F) Sqn at RAF Valley, was Above Average. The report from his recently completed Refresher Course on XV(R) Sqn concurred with this assessment. Witness 3, Annex B, Exhibit 3

3. Weapon System Operator's (WSO's) Background. At the time of the accident, Flt Lt [redacted] was a Combat Ready (CR) WSO, Electronic Warfare Instructor and Qualified Navigation Instructor on 31 Sqn who was 2 years and 6 months into his first tour with the RAF. Previously, Flt Lt [redacted] was a member of the [redacted] serving as a CR Navigator on Hercules and F-111 Sqns before teaching at the [redacted] School of Air Navigation. He had a total of 1870 flying hours, of which 621 hours were on the Tornado GR4 and his last flying assessment, dated 30 Apr 06, was High Average. Witness 4, Annex B, Exhibit 4

4. Aircraft Background. ZG711 was a Tornado GR4A. The ac had not been subject to any Incident or Birdstrike Reports since Dec 03, over 644 flying hours prior to the accident. On the morning of 24 Oct 06, ZG711 was in B14 fit, as described in the RAF's Release to Service, comprising 2 x 2250 litre underwing tanks, LAU-7A launchers on the inboard pylons, a single AIM-9L acquisition missile on the left inboard stub pylon, a BOZ 107 Pod on the right outboard pylon, a Skyshadow Pod on the left outboard pylon and 2 Carrier, Bomb, Light Stores, loaded with four 3kg Practice Bombs each, on the shoulder pylons. The ac was assessed as fully Annex C, Exhibit 5

[redacted]

serviceable.

a. Airframe. Prior to the accident, ZG711 had flown a total of 4217:15 hours and 135:55 hours had elapsed since its last Primary Star maintenance. This servicing was carried out within the Forward Aircraft Maintenance Flight at RAF Lossiemouth. According to the Logistics Information Technology System (LITS), at the time of the accident ZG711 had 127 Special Instructions (Technical) (SI(T)) and 142 modifications outstanding. Annex C Annex E

b. Engines. Rolls Royce RB199 Mk 103 Engine Change Units (ECUs) serial numbers 6510 and 6749 were fitted to ZG711. Both ECUs had previously been reconditioned at RAF Marham Tornado Propulsion Facility. The right hand ECU (6510) was last reconditioned on 3 Nov 03, installed into ZG711 on 20 Nov 03 and had run for 648 hours prior to the accident. The left hand ECU (6749) was last reconditioned on 14 Jun 06, installed into ZG711 on 26 Jun 06 and had run for 96 hours prior to the accident. Annex C Annex S

5. Previous 24 Hours. On the day prior to the accident, Sqn Ldr [redacted] and Flt Lt [redacted] flew together as the lead ac of a pair. The pilot of the No 2 ac in the formation had recently returned from operations in the Gulf and this was his first sortie back in the UK. The content of the sortie was kept simple and the aim was to complete a range detail at Holbeach AWR followed by a low-level route in Wales. In the AWR, the No 2 ac suffered a birdstrike on the second pass. After a visual inspection, which did not identify any damage, the No 2 ac recovered safely to RAF Marham. The lead ac returned to the AWR and completed the range detail before flying the planned low-level route in Wales as a singleton. After a short debrief, Flt Lt [redacted] left the Squadron at 1700hrs and Sqn Ldr [redacted] completed paperwork in his office before leaving at 1800hrs. Neither crewmember was on medication; neither drank alcohol during the evening. Sqn Ldr [redacted] went to bed at 2230hrs and Flt Lt [redacted] went to bed at 2300hrs. Both slept well and were fully rested next morning. Witnesses 1/2/5 Exhibit 6

6. Planning. On the day of the accident, the crew arrived at work at 0745hrs. They were programmed to lead a pair on a medium-level CAS Ex sortie in Low Flying Area (LFA) 5, a role for which they were fully qualified. The formation constitution (callsigns Spartan 1 and 2) was the same as the previous day, with the exception of the No 2 WSO. The Duty Authoriser gave a meteorological briefing at 0800Z, after which Sqn Ldr [redacted] checked the detailed weather in the CAS Ex area with the Duty Forecaster. The weather was unfit for medium-level operations and it was decided to conduct low-level CAS. There was 30 minutes available between the planned take-off and the on-station time for the CAS Ex and, since it was also the week of the 31 Sqn Bombing Competition, it was decided to complete a range detail before carrying out the CAS Ex. Sqn Ldr [redacted] discussed the aims of the sortie with the rest of the formation and elected to fly a 'Large Charge' through the Wash AWRs followed by a simple low-level CAS Ex. (The 'Large Charge' involves consecutive First Run Attacks (FRAs) at Holbeach, Wainfleet and Donna Nook AWRs, with Witnesses 1/2/5/6 Witness 7 Annex F

handovers between each Range Safety Officer (RSO) to simplify radio transmissions.) FRAs were booked at each range and a slot booked at Donna Nook to allow the formation to complete a full range weaponeering detail. Exhibit 7

7. Pre-Flight Briefing, Authorisation and Walk. The brief lasted approximately 25 minutes and Sqn Ldr [redacted] and Flt Lt [redacted] concentrated attention on the range detail, the range emergencies and the CAS Ex. The initial part of the outbrief was carried out by the Duty Authoriser and completed by Flt Lt [redacted] who also authorised the sortie. The crew was driven to the ac, which was ready for crew-in. Witnesses 1/2/5/6 Witness 7

8. Start-up, Taxi and Take-off. Two minor problems were experienced during initial crew-in. The first problem was a Stores Management System channel fault and the second was a persistent L THROT (left engine control lane failure) caption; both problems cleared with the assistance of engineering trade cover. The remainder of the start-up was uneventful and the formation taxied 2 minutes late, a delay further increased by a change to Runway 24. A right hand turnout was requested from Air Traffic Control to regain the timing for the FRA and the formation flew a 20 second stream take-off at 1055hrs. Witnesses 1/2/8/9

9. Transit. Once airborne it became apparent that the weather in the vicinity of RAF Marham was unfit for a low-level transit to Holbeach AWR. Consequently, Spartan 1 climbed to 2000ft, positioning above a thin layer of cumulus cloud, and Spartan 2 climbed to 4000ft. The planned route, detailed on a map at Exhibit 7, coasted out north-bound abeam Langham before turning west and maintaining a shoreline track around the Wash coast, a distance of some 20 miles, before intercepting the final attack heading for Target 6N at Holbeach AWR. Sqn Ldr [redacted] transmitted his intentions to intercept the route short of Waypoint 'W' (5nms north of Hunstanton). The formation established radio contact with Holbeach AWR; the RSO gave the weather conditions in the range as wind 300/15kts, visibility 6km in haze, 1/2 octas of cloud at 800ft and 5/6 octas of cloud at 1800ft. Spartan 1 completed the Pre-Low Level and Pre-Target/Range Checks and subsequently descended into low level abeam Hunstanton, levelling at 280ft Rad Alt and 420kts KCAS. By this time Spartan 1 was heading south and running 10 seconds early and the crew manoeuvred the ac slightly left of the planned track in order to make good the FRA time of 1104:00hrs. The ac was in 'Main' navigational mode as the Global Positioning System was unserviceable and a pre-attack height fix was therefore carried out over the sea. The ac coasted-in on the southeastern edge of the Wash at 285ft Rad Alt and 442kts KCAS. At 1102:20hrs Spartan 1 commenced a right hand turn onto the final attack heading for Target 6N at Holbeach AWR. Witnesses 1/2/5/6 Exhibit 7 Annex G Witnesses 1/2 Exhibits 2/16 Annex H

10. Birdstrike. At 1102:29hrs, in a right hand turn with 23 degrees angle of bank, passing through a heading of 202 degrees, at 380ft Rad Alt and 436kts KCAS, Spartan 1 flew through a large flock of birds and experienced multiple birdstrikes. The REHEAT caption illuminated, a machine gun popping type noise was heard and both engines experienced Exhibit 2 Witnesses 1/2

a marked loss of thrust. At the moment of impact with the birds, the Accident Data Recorder (ADR) trace shows that the right VIB caption also illuminated for 5 seconds but Sqn Ldr [redacted] does not recall seeing this. The right jet pipe nozzle area (Aj) failed to Emergency Nozzle Closed and the nozzle area reduced to 7%. Annex H Exhibit 8 Witness 1

11. Immediate Actions. Post-birdstrike, Sqn Ldr [redacted] immediately initiated a wings level climb and advanced both engine throttles to Max Dry but neither engine responded to throttle demand and the Engine High Pressure Compressor Spool Speeds (NHs) started to decay. Sqn Ldr [redacted] remarked that there had been a major birdstrike and transmitted this information on Holbeach AWR Primary radio frequency. The throttles were then individually retarded to idle. The left NH responded and quickly reduced and stabilised at 69% (nominal flight idle). There was no noticeable response from the right engine and the right NH continued to run down and stagnated between 71 and 72%. Flt Lt [redacted] asked if there were any other indications of failure, including engine mechanical failure. Sqn Ldr [redacted] replied that he was checking for other indications. Both throttles were then advanced to a mid-power setting and the left NH increased to 82% but the right NH remained unchanged. Sqn Ldr [redacted] stated that neither engine was responding normally and retarded both throttles to idle. The left NH reduced and stabilised at 68%. The right NH reduced slowly over the next 12 seconds from 71 to 66% (sub-idle). Prompted by Flt Lt [redacted] Sqn Ldr [redacted] made a Mayday call on Holbeach AWR Primary radio frequency. At this point, Flt Lt [redacted] suggested RAF Marham as a suitable diversion, selected navigational steering to the airfield and squawked emergency. Sqn Ldr [redacted] began a right turn towards the Wash and attempted further engine diagnosis. The ac reached 2410ft Rad Alt and 280kts KCAS, the wings were swept forward to 25 degrees wingsweep and the right turn was continued on to a heading of 328 degrees. Once again the throttles were brought up to a mid-power setting. However, as the left NH increased through 83% the left engine sounded as if it was pop surging. At the same time, the right NH did not rise above 68%. Both throttles were again retarded to idle. At this point 45 seconds had elapsed since the birdstrike. Annex H Annex G Annex G

12. Subsequent Actions. At 1103:13hrs the ac began to descend and Sqn Ldr [redacted] closed the right High Pressure (HP) Cock and immediately relit the right engine. The engine relit successfully and the NH rose to 68% after approximately 20 seconds but did not then respond normally to throttle demand. Sqn Ldr [redacted] commented that the engine had relit in surge and he later recalled that the needle on the Turbine Blade/Bearing Temperature (TBT) gauge was in the 2 o'clock position (approximately 800 degrees C); the Air Accidents Investigation Branch (AAIB) report concurred with this, stating that the right engine TBT indicated 792.5 degrees C whereas the left engine TBT indicated 402.5 degrees C. At the same time, he advanced the left throttle in an attempt to get more thrust out of the left engine. The left engine initially responded to throttle demand but again the left engine sounded as if it was pop surging as NH increased to 83%. Descending through 1000ft Rad Alt, Sqn Ldr [redacted] prompted Flt Lt [redacted] to prepare to jettison the underwing fuel tanks Annex H Witness 1 Annex I

and Flt Lt [redacted] selected the tanks on the Weapons Control Panel and uncovered the jettison button. At the same time, Sqn Ldr [redacted] closed the right HP Cock and then relit the right engine for the second time. The relight was successful and the right NH rose to 69% after approximately 19 seconds but, once again, the right engine did not respond to throttle demand. Passing 700ft Rad Alt, Flt Lt [redacted] called for Sqn Ldr [redacted] to tighten his restraint harness straps. A few seconds later, he firmly stated that the height was down to 500ft Rad Alt and asked if Sqn Ldr [redacted] wished to jettison the underwing fuel tanks. Sqn Ldr [redacted] replied in the affirmative and at 380ft Rad Alt. following confirmation that the area ahead of the ac was clear, Sqn Ldr [redacted] selected the Master Armament Safety Switch (MASS) to live and Flt Lt [redacted] jettisoned the tanks. At this point the left throttle was advanced but, at 83% NH, the left engine again sounded as if it was pop surging. Sqn Ldr [redacted] closed the left HP Cock and immediately relit the left engine. Flt Lt [redacted] called that the height was now 300ft Rad Alt. Sqn Ldr [redacted] advanced the right throttle in an attempt to get more thrust out of the right engine but the engine stagnated at 67% NH despite the throttle demand. As the ac descended through 250ft Rad Alt, Flt Lt [redacted] forcefully suggested that an abandonment decision be made soon and Sqn Ldr [redacted] transmitted the intention to eject on Holbeach AWR Primary radio frequency. Annex G

13. Ejection. Flt Lt [redacted] initiated the command ejection sequence at 1104:30hrs at 160ft Rad Alt and 204kts KCAS. The total time from birdstrike to ejection was 122 seconds. Witnesses 1/2 Annex H

14. Pilot Survival Aspects. Sqn Ldr [redacted] recalled being "heads in" trying to rectify the engine problems and transmitting the intention to eject when the navigator initiated ejection; as a result he had no time to adopt the ideal ejection posture and was flexed slightly forward. The seat acceleration compounded his forward flexion and he described himself as being "bent double". He was aware of a bright flash at the moment of ejection, followed by darkness, and then felt the snatch of the parachute opening. He spun around in his parachute and saw Flt Lt [redacted] with his Personal Survival Pack (PSP) dangling. Owing to the close proximity of the ground he had no time to carry out any parachute descent drills before ground impact, although he described that he was able to adopt a good parachute landing posture. Sqn Ldr [redacted] experienced lower back pain during the ejection sequence and tried, on landing, to roll himself onto his side to avoid aggravating any injury. He was dragged a short distance before he was able to adopt a stabilised 'starfish' position and remove his parachute harness. As the PSP landed in the shallow water the automatic inflation squib was activated and the life raft inflated. Given his back pain, Sqn Ldr [redacted] elected to remain motionless and await rescue. Approximately 25 minutes after the ejection, a Royal Navy (RN) Commando Sea King helicopter landed near the crew and administered first response treatment; the helicopter was not equipped for casualty removal but the crewman provided warm clothes and reassurance. Approximately 45 minutes after the ejection, two RAF SAR Sea King helicopters arrived. Having established Sqn Ldr [redacted] condition, including [redacted] his Aircrew Equipment Assembly (AEA) was Witness 1 Annex D

cut off, his jacket and helmet were removed and he was placed onto a spinal immobilisation stretcher. Owing to the muddy conditions in the Wash, it was considered unsafe to manually carry him to the helicopter and he was winched onboard before being flown to hospital in King's Lynn.

15. WSO Survival Aspects. Prior to initiating ejection Flt Lt [redacted] tightened his restrain harness straps and adopted a good ejection posture with his head against the ejection seat headbox. He remained conscious throughout the ejection sequence and recalled a short pause after pulling the ejection handle before the cockpit filled with smoke and flames. He was aware of being shaken around in his parachute and, when he looked down, realised he was close to the ground. There was insufficient time to complete any parachute descent drills other than adopting a parachute landing posture. He saw his PSP hit the ground and the lanyard spiralled quickly down beside it. His landing was soft into mud but he was flipped onto his front and dragged along the undulating surface. Flt Lt [redacted] stabilised himself by using the 'starfish' position and was then able to remove the parachute harness. Flt Lt [redacted] experienced pain in the top of his right leg and both shins. After checking for fractures, he pushed himself into a sitting position on a raised area of mud, clear of the water. Flt Lt [redacted] noticed the ac catch fire and saw Sqn Ldr [redacted] lying still. He checked his Personal Locator Beacon was activated and prepared his mini-flares. He considered firing a flare to signal to Spartan 2, who was still overhead, but elected not to do so. Flt Lt [redacted] also received assistance from the crew of the RN Commando Sea King helicopter. The crewmen from the second of the 2 RAF SAR Sea King helicopters experienced great difficulty manoeuvring Flt Lt [redacted] onto the spinal immobilisation stretcher because of the very muddy conditions and he was eventually winched onboard and taken to hospital in King's Lynn. Witness 2 Annex D

16. Aircraft Impact. At approximately 1104:35hrs the ac impacted the Wash at a shallow angle in a wings level, nose-up attitude. It skipped over the mud before hitting the ground for a second time, at which point the cockpit section broke away from the main fuselage. A post-crash fire developed and the centre fuselage was extensively damaged. There was no fire damage to the cockpit section. The ac wreckage was located within the tidal zone of the Wash and suffered further damage from the scrubbing action of the tide. Annex I

17. Aircraft Recovery. The recovery of the wreckage proved difficult because of the ac's position on the tidal mud flats of the Wash, about one km offshore, and involved Hagland 4-track drive vehicles (BVs), 'Jetfloat' modular pontoons, a RN Merlin helicopter, a RAF Chinook helicopter and a hovercraft. It was 12 days before all the wreckage was eventually lifted onto a barge and transferred to a hangar at RAF Marham. Annex J

18. Conclusions. The Board concludes that:

a. Sqn Ldr [redacted] and Flt Lt [redacted] were on duty at the time of the accident. Witnesses 1/2/3/4/7

b. The flight was properly authorised. Witnesses 1/2/7

c. The flight was adequately briefed. Witnesses 1/2/5/6

d. The crew was competent to undertake the flight. Witnesses 3/4

e. The ac was serviceable to undertake the flight. Witnesses 8/9

f. The weather was suitable for the flight. Annex F

AIRCRAFT ESCAPE AND SURVIVAL FACILITIES

19. The crew ejected at 160ft Rad Alt and 204kts within the safe ejection envelope for the Martin Baker Mk10A ejection seat. During eiection, Sqn Ldr [redacted] he had not adopted a good ejection posture. In contrast, Flt Lt [redacted] tightened his harness and was sitting upright with his head against the headbox when he initiated ejection and [redacted] Annex K

20. The lifepreserver stole worn by Flt Lt [redacted] was not inflated during the ejection sequence and it remained contained in the stole cover. During the post ejection examination of the survival equipment at the RAF Centre Of Aviation Medicine (CAM), the stole was inflated by pulling the manual-operating handle. The stole only partially inflated. There was no obvious indication as to why the stole failed to inflate fully. The most likely explanation for the stole not inflating fully is the carbon dioxide (CO_2) cylinder was not fully charged; hence there was insufficient gas to fully inflate the stole. The CO_2 cylinder is weighed prior to fitting to the lifepreserver jacket to indicate the CO_2 content but this weight is not recorded and, as a result, it is not known what the cylinder weight was prior to the accident. Annex K

21. The Board concludes that the ac escape facilities were fully utilised and worked normally with the exception of the WSO's lifepreserver.

DEGREE OF INJURY

22. The Board found that:

a. Service Personnel. [redacted] Annex K

b. Civilian Personnel. There were no injuries received by civilian personnel.

DAMAGE TO AIRCRAFT, PUBLIC AND CIVILIAN PROPERTY

23. Aircraft. ZG711 suffered Category 5 (scrap) damage. Annex L

24. Public Property. There was no damage to public property.

25. Civilian Property. No damage was caused to civilian property by the actual ac crash. However, the following compensation has been paid in respect of civilian property damaged during the course of the recovery operation: Annex M

a. The sum of £75.00 to W H Kirkham Ltd, Rhoon Farm, Terrington St Clements for crop damage.

b. The sum of £500.00 to L Simmington Farms Limited, Balaclava Farm, Terrington St Clements for damage to the farm road.

c. The sum of [redacted] to DG Scales Plant Hire Limited for ground restoration work.

DIAGNOSIS OF CAUSES

26. Introduction. The Board had a considerable amount of evidence available from an early stage in the investigation, including ADR data, the mission video tape recording and the statements of the crew and eyewitnesses. Following a full analysis of the data available and extensive interviews, the Board was able to discount mid-air collision, airframe structural failure, ac mishandling, and weather as factors in the accident; therefore the Board concentrated its investigation on the effect of the birdstrikes on ZG711.

27. Available Evidence. To assist the Board in their deliberations, the following were available:

a. ADR. ADR data, including voice recording, for the whole flight up to the point of ground impact was available within 48 hours. The ADR trace proved invaluable in determining the sequence of events Annex H

during the accident; however, it was noted that the Tornado GR4 ADR does not record Turbine Bearing/Blade Temperature (TBT).

b. Mission Video Tape Recording. A mission video tape recording of the sortie including Head-Up Display (HUD), Forward Looking Infra Red, Radar and WSO Television/Tabular (TV/TAB) Display video up to the point of ground impact was available within 48 hours. — Exhibit 2

c. Air Accidents Investigation Branch (AAIB) Inspector. An AAIB inspector completed the detailed technical investigation of the wreckage at the crash site. — Annex I

d. Witnesses. The pilot, WSO, other formation members, the Duty Authoriser, personnel from 31 Sqn and RAF Marham, civilian eyewitnesses and the Holbeach RSO all gave witness statements. — Witnesses 1-11

e. Human Factors Consultant. Mr John Chappelow, a human behavioural scientist, investigated human factors in the accident. — Annex N

f. Service Technical Experts. A variety of Service technical experts including the Aircraft Recovery Officer (ARO), Aircraft Recovery & Transportation Flight (ARTF) and the Accident Investigation Team from RAF CAM gave invaluable support. — Annex J, Annex K

g. External Technical Experts. A variety of external technical experts including representatives from Rolls Royce (RR), BAE Systems, QinetiQ and the Central Science Laboratory (CSL) provided significant assistance. — Annex O, Annex P, Annex Q

28. Factors Considered By The Board. The Board considered the following factors might have had a bearing on the accident:

a. Pre-Birdstrike:

(1) Birdstrike reduction measures.

(2) Study of bird activity in the Wash AWRs.

(3) Aircraft height during coast-in.

b. Post-Birdstrike:

(1) Birdstrike damage to RH engine.

(2) Birdstrike damage to LH engine.

(3) Birdstrike damage to airframe.

(4) Jettison of external stores.

[redacted]

DISCUSSION OF FACTORS

29. Birdstrike Reduction Measures. The Board considered the following facts when deciding if the existing birdstrike reduction measures had any bearing on the accident:

a. UK Military Aeronautical Information Publication (UK Mil AIP). Exhibit 9
The guidance given in the UK Mil AIP (Volume 3, Part 1, Section 1, Para 01.03.11) regarding warnings of bird concentrations states that, "when operating in coastal regions or during periods of bird migration, aircrew are advised to consult Bird Avoidance Model Geographical Information Service (BAMGIS) data during the sortie planning process to ensure they are in possession of warnings of bird concentrations." The following additional guidance regarding high bird concentrations in LFA 5 is given in the UK Mil AIP (Volume 3, Part 1, Section 2, LFA 5 Warnings), "crews are reminded that, as with many coastal regions of the UK, the North Norfolk Coast has very high concentrations of birds. This is especially so during the period of Sep-Feb when large flocks of geese migrate from Scandinavia. Feeding areas can be found as far as 5nm inland whilst the roosts are mainly confined to woodlands around the coastal area. Up to date information can be obtained from BAMGIS, and crews are reminded to consult this media during planning."

b. Group Air Staff Orders (GASOs). The following guidance is Exhibit 10
given in GASOs (1G310.220) regarding procedures to minimise birdstrike hazard in the UK, "all 1 Gp crews operating in the UK are to comply with the procedures for minimising birdstrike hazards contained in the UK Mil AIP Vol 3 (UK Military Low Flying System). Low-flying activity in areas of known high bird concentrations within coastal AWRs is permitted in accordance with Strike Command Air Weapons and Electronic Warfare Range Orders (STCAWEWROs), provided the Range Safety Officer (RSO) gives an indication of low bird activity".

c. RAF Marham Birdstrike Reduction Measures. The RAF Exhibit 11
Marham Flying Order Book contains an order (local area L4) entitled "Risk of Birdstrikes", but this only addresses the birdstrike risk in the immediate vicinity of the airfield and not the nearby Wash AWRs.
The subject of birdstrike risk to Marham based ac was discussed Exhibit 12
routinely during quarterly Station Flight Safety Committee meetings and, in particular, the need to balance the inherent birdstrike risk when operating at low level with the achievement of basic training requirements. In addition, there was much discussion regarding the usefulness of the information generated by BAMGIS and the inability to integrate BAMGIS data into the Tornado Advanced Mission Planning Aid (TAMPA).

d. BAMGIS. The Board considered the utility of BAMGIS in its current form:

[redacted]

(1) Format And Integration. BAMGIS data is updated monthly and is available on the UK Military Aeronautical Planning Document (UK Mil APD) CD, issued by No 1 Aeronautical Information Documents Unit (AIDU) to all units. More specifically, BAMGIS information is currently presented in a basic format with small circles in three shades of red indicating low, medium and high bird activity, the definitions of which are not defined within the document. Exhibit 13 Exhibit 14

(2) Predictive Accuracy of High Risk Birdstrike Areas. In a Station Flight Safety Meeting at RAF Marham on 1 Jun 05, the Chairman tasked the Station Flight Safety Officer (SFSO) to undertake a basic analysis of recent birdstrikes and compare their location to the areas of high bird activity as detailed in UK MIL APD Section 8. The SFSO found only one birdstrike in the previous year occurred within a predicted high-risk area. Furthermore, the BAMGIS model appeared to correlate poorly with the local knowledge of positions of areas of high bird concentrations; for example, The Plug at Holbeach is known to have a large population of birds and yet BAMGIS does not indicate this. BAMGIS's prediction of bird activity for the day of the accident indicates no more than moderate bird activity within Holbeach and indicates none at the immediate point of the birdstrike. Exhibit 12 Witness 11 Exhibit 15 Witness 11 Exhibit 14 Exhibit 14

30. The Board considers that the guidance given in the UK Mil AIP and GASOs regarding procedures to minimise birdstrike hazard in the UK was clear. The Board also considers that the RAF Marham birdstrike reduction measures were satisfactory. However, BAMGIS, in its current form, is not utilised by planning crews to aid their awareness of high bird activity. The Board considers this a result of the system's lack of integration into TAMPA and its construed inaccuracy. Had BAMGIS been consulted on this occasion, the service would not have warned the crew of any increased bird activity along the route they had planned.

31. The Board concludes that the existing birdstrike reduction measures were not a factor in the accident. However, the Board also concludes that the lack of a readily available and accurately predictive bird avoidance model was an other factor.

32. Study of Bird Activity in the Wash AWRs. In Dec 04, following a series of birdstrikes involving ac engaged in activities at Holbeach and Wainfleet AWRs, DASC commissioned the CSL to conduct a 2-day on-site birdstrike study of the Wash AWRs. The aim of the study was to establish if the likelihood of a birdstrike could be reduced by controlling certain aspects of range activity around times of increased bird activity and was conducted on 19/20 Jan 05. The Holbeach and Wainfleet Weapons Ranges Bird Hazard Study document detailed the results of the study and included the following information regarding risk reduction: Annex Q

a. A Birdstrike Risk Reduction Strategy. The study stated that, in order to minimise the risk to aircraft, it would be necessary to attempt to find a strategy that avoided the hazard. In particular, the easiest way of avoiding the risk would be to move ac routes over the open sea wherever possible. If it were possible to change the close circuit patterns so there was less time spent flying along the coast, the risk would similarly be reduced.

b. Achieving the Fullest Risk Reduction. Given the very short exposure of the study and the limited range of environmental conditions experienced, it was deemed difficult to extrapolate the findings to the other situations, such as seasonal variations and tidal patterns, that occur. The study recommended that HQ 1 Gp commission a more detailed study of bird activity within the Wash Weapons Airspace in order to develop a more robust risk reduction strategy for ac using the Wash AWRs.

33. The Board considers that the recommendations of such a short study were unlikely to be used in isolation as other important considerations such as training aims and noise pollution restrictions must also be addressed. The need to balance the known birdstrike risk with all other factors requires careful consideration and only a more detailed study, encompassing all environmental conditions, would allow an acceptable level of compromise to be achieved. Without knowing the exact nature of changes to range operations derived from the recommendations of the CSL bird study, the Board cannot say, with any certainty, whether the employment of such measures would have made the accident any less likely. The Board believes that existing birdstrike measures should first be fully evaluated before a more detailed study of bird activity is undertaken. Exhibit 19

34. The Board concludes that the lack of implementation of the recommendations from the CSL Bird Hazard Study was not a factor in the accident. However, the Board also concludes that the lack of a recent evaluation of bird activity within the Wash Weapons Airspace was an other factor in the accident.

35. Aircraft Height During Coast-In. The Board considered the following facts concerning whether the aircraft height at coast-in had any bearing on the accident:

a. UK Mil AIP. The UK Mil AIP (Volume 3, Part 1, Section 1, Para 01.03.11) states that, "whenever possible, coastlines are to be crossed at right angles and as a general rule, at a minimum of 500ft Minimum Separation Distance to reduce the risk of birdstrike". Exhibit 13

b. GASOs. GASO 1G310.220.3, entitled 'Crossing of Coastlines', is more stringent and states that, "whenever possible, 1 Gp ac are to cross all coastlines (UK and abroad) at right angles, and at a height of not less than 1000ft. This order does not apply when operating within an AWR under the supervision of an RSO". Exhibit 10

c. The crew of ZG711 coasted in on the south-eastern edge of the Wash at a height of 285ft Rad Alt. When the birdstrike occurred, ZG711 was 2nm outside the Holbeach AWR (EG D207) but well within the Wash Weapons Airspace (PMR 225) and the crew were in radio contact with the Holbeach RSO. Exhibit 16

d. Analysis of recent birdstrike data provided by the SFSO at RAF Marham indicated that less than 9% of the birdstrikes involving RAF ac occurred above 500ft. Exhibit 15

36. The Board considers that, given the close proximity of the ac to the south-eastern edge of the Holbeach AWR, its position within the Wash Weapons Airspace and the fact that the crew were in radio contact with the RSO on the range primary radio frequency, it was not unreasonable for the crew to believe that the dispensation contained within GASO 1G310.220.3 applied, and that they were not required to be at 1000ft or above. Annex G

37. In addition, the Board considers that climbing to 1000ft or above while only 8nm from the target would have made the achievement of the standard operating run-in height for this attack, level at 150ft, almost impossible.

38. The Board considers that, given the analysis of recent birdstrike data, had ZG711 flown at or above 500ft on coast-in prior to turning onto the final attack heading, the chances of sustaining a birdstrike would have been reduced.

39. The Board concludes that the aircraft height at coast-in was a contributory factor to the accident.

40. Birdstrike Damage to the Right Engine. The Board considered the following facts when deciding if the birdstrike damage to the right engine had any bearing on the accident:

a. There was extensive damage to the front of the Low Pressure (LP) compressor. The nose bullet (Air Intake Fairing Assembly) suffered extensive impact damage resulting in the release of approximately 30% of its mass (450g). The released material was ingested into the engine causing extensive hard object damage to the LP, Intermediate Pressure (IP) and High Pressure (HP) compressor rotor blades and stator vanes. Slight soft body damage was found on the HP compressor and bird remains were found in the lower HP3 heat exchanger. Annex O

b. Analysis of the bird remains showed that the birds ingested were from the grey goose species that has an average weight range of 1800 to 3325g. The RB199 engine specification (TU473) does not require the engine to continue operating following the ingestion of a bird with a mass greater than 454g. Annex Q

41. The damage to the engine is consistent with a large bird striking the nose bullet, which then broke up and passed through the right engine, causing extensive damage. The reduction in performance of the right engine, as assessed from the ADR, was commensurate with the mechanical damage seen on the engine compressors.

42. Birdstrike Damage to the Left Engine. The Board considered the following facts when deciding if the birdstrike damage to the left engine had any bearing on the accident:

> The left engine was visually in much better condition than the right engine. During the strip of the engine, soft body damage was found to the LP compressor stage 3 rotor blades and the HP compressor across stages 1,2 and 3. In addition to the recovery of small feathers on the bypass annulus, burnt-on bird remains were evident on the engine casing. Hard body damage was found throughout the LP, IP and HP compressors. — Annex O

43. The damage to the left engine was consistent with the ingestion of a bird directly into the LP compressor blade path, resulting in soft body damage that caused clashing of the LP blades. This clashing brought about the disintegration of sections of the blade, which in turn caused a small amount of hard body damage to the LP, IP and HP compressors. Despite the extensive damage to the engine, the left engine continued to operate up to around 82% NH where the engine audibly pop surged. This correlates with the engine speed at which the IP bleed valve automatically closes and reduces the surge margin of the engine by 7%. There is no data available to correlate the damage to the engine compressors with the reduction in performance and engine surge margin; however, the Rolls Royce report states that this performance is commensurate with the mechanical damage sustained. — Annex O

44. The Board concludes that the birdstrike damage to the right and left engines was the cause of the accident.

45. Birdstrike damage to Airframe. The Board considered the following facts when deciding if the birdstrike damage to the airframe had any bearing on the accident:

> a. There was an area of delamination on the outside of the nose cone and also several cracks on the inside of the nose cone where the delamination occurred. — Annex I
>
> b. There was a 'soft dent' in the upper surface of the right wing slat and cracking on the lower wing surface. — Annex I
>
> c. There was no evidence of a bird having struck any part of the tail section or the leading edges or auxiliary doors on either of the intakes; however, due to the extent of the post-crash fire it was not possible to establish if a bird had struck the internal structure of the — Annex I

air intakes.

d. The external fuel tanks had fragmented into a large number of pieces. The bulkheads, tail section and skin on the left tank were considerably more damaged than the items fitted to the right tank. Given that both external fuel tanks were jettisoned at the same time, and landed in the same type of ground, it is possible that the difference in damage to the tanks was a result of them containing different amounts of fuel. Eyewitness accounts also indicate the possibility that the left underwing fuel tank may have ruptured prior to jettison. Annex I Witness 5

e. Comparison of the ADR data before and after the birdstrike revealed no appreciable difference in the control surface response to the control column inputs. Annex H

46. Investigation of the airframe wreckage revealed possible evidence of multiple birdstrikes but no pre-crash fire. The damage to the nose cone, right wing slat and left underwing fuel tank is consistent with that caused by birdstrikes; however, the Board believes that none of these birdstrikes affected the handling qualities of the aircraft.

47. The Board concludes that the birdstrike damage to the airframe had no bearing on the outcome of the accident.

48. Jettison of External Stores. The Board considered the following facts when deciding if the jettison of external stores had any bearing on the accident:

a. Thirty-five seconds elapsed between when the pilot prompted the WSO to prepare to jettison the underwing fuel tanks and when the tanks were actually jettisoned. During that time, the ac descended from 1485ft to 380ft Rad Alt. For the pilot, much of this time was taken up attempting to get a working level of thrust from at least one engine to maintain safe flight. The WSO was not distracted by having to deal with the engine problems and maintained an awareness of the need to complete the jettison process, requiring the pilot to switch the MASS to live before the WSO was able to jettison the tanks. He subsequently prompted the pilot as the situation became critical and the tanks were jettisoned. Exhibit 2

b. During training on the Tornado GR4, the jettison of stores is taught as a crew event, not necessarily the independent action of the pilot, and is therefore more protracted than it would be in a single seat ac due to the discussion and co-ordination involved.

c. Crews are also trained to ensure that jettisoned stores do not result in unnecessary injury to anyone on the ground. The land to the south east of Holbeach AWR accommodates many buildings and the city of Kings Lynn lies slightly further to the south. By initiating a turn away from these areas, the pilot positioned the

aircraft in the safest position to jettison stores without endangering life.

d. BAE Systems performance calculations indicate that the thrust available once the tanks were jettisoned was still only approximately 50% of that required to sustain level flight. The performance report further states that, even if all of the external stores had been jettisoned, there was insufficient thrust available to save the ac. Annex P

49. The Board considers that there were many factors affecting the jettison of the underwing tanks, notably training and safety considerations, as well as the need to achieve a working level of thrust to maintain safe flight. The BAE Systems performance report states that the thrust available was insufficient to save the aircraft.

50. The Board concludes that the jettison of external stores had no bearing on the outcome of the accident.

RELEVANT DOCUMENTATION

51. The Board reviewed all relevant orders, instructions and documentation and concluded that they had no bearing on the loss of ZG711. Furthermore, the Board can certify that all relevant documents pertaining to the flight have been inspected and any inadequacies have been recorded. The Board noted the following points:

a. Engineering.

(1) MOD Form 700. A full Quality Assurance (QA) check of ZG711's MOD Form 700 was carried out iaw DAP101B-4100-2(R)1 Leaflet 031. Annex R details a number of minor observations. Annex R Exhibit 5

(2) Relevant Engineering Documentation. A full QA of all engineering documentation including airframe, engine and component log cards was carried out iaw JAP100A-01 Chap 15.2. The engineering documentation was generally of a high standard and a number of minor points can be found at Annex S. Annex S

(3) Maintenance Procedures. The Board found that all relevant maintenance procedures were complied with. Witnesses 8/9

(4) Engineering Order Books. The Board found no concerns with the standard of RAF Marham's Aircraft Engineering Standing Orders.

b. Flying. The Board found no inadequacies in the flight authorisation sheets, aircrew flying log books, flying order books, RAF Form 5000 series, aircrew training folders and other relevant Exhibits 3/4/6/7/17

military publications.

CONSIDERATION OF HUMAN FACTORS

52. Human Factors. The crew were formally interviewed by Mr John Chappelow to assess Human Factors in relation to the accident. His report stated that the crew were not well acquainted before this sortie but they cooperated well throughout the critical period and stated that there was no evidence of an inappropriate authority gradient. Assessing the crew's actions individually, the report stated that Sqn Ldr [redacted] responses to the situation did not appear rushed, but there were many phases of activity as he explored the problem and the strategies available to him. There was little to indicate which engine would provide the best chance of a successful relight and all his actions were consistent with addressing this dilemma. Of note, Sqn Ldr [redacted] informal and formal interviews showed discrepancies between his recollection and the objective record. The 2 minutes of flight from birdstrike to ejection were undoubtedly demanding and some effects on Sqn Ldr [redacted] recollection of events were to be expected as he rationalised, or confused, memories of actions taken at different stages of the critical period. Assessment of Flt Lt [redacted] actions showed that he maintained a keen awareness of the overall developing situation. Whilst allowing the pilot the opportunity to diagnose and deal with the engine failures, he ensured key decisions, such as the transmission of a Mayday call, the jettison of the underwing tanks and the ejection, were all completed in a timely manner. In summary, the report stated that the crew handled an intractable emergency in a professional manner. Annex N

53. Ejection. After the birdstikes, the ac flew for approximately 2 minutes, climbed to 2410ft Rad Alt and descended to 160ft Rad Alt when ejection occurred. Throughout this critical period, the crew made repeated unsuccessful attempts to obtain a working level of thrust from at least one engine. The Board applauds the crew's attempts to examine all possible avenues to recover the situation, but believed that the crew was experienced enough to realise that the situation was fast becoming irrecoverable. Therefore, although ejection occurred within the safe working envelope for the Martin Baker Mk10A ejection seat, an earlier ejection decision would have afforded Sqn Ldr [redacted] time to adopt an appropriate ejection posture. Exhibit 2

RELEVANT ORDERS AND INSTRUCTIONS

54. All relevant orders and instructions were complied with, although, at RAF Marham, local knowledge and experience of areas of bird activity were preferred as a more accurate indicator of birdstrike risk than the information available from BAMGIS. Witness 11

SUMMARY OF CAUSES AND FACTORS

55. Cause(s). In view of the overwhelming evidence available, the Board considers that the accident involving ZG711 was a direct result of:

The ingestion of a number of birds into the engines, which caused the mechanical failure of both engines and resulted in the ac being unable to sustain flight. Annex O Annex P

56. Contributory Factor(s). The Board identified the following contributory factor that did not directly cause the accident but made it more likely to happen:

Operating below 500ft in an area of known bird activity. Exhibits 13/15

57. Aggravating Factor(s). There were no aggravating factors.

58. Other Factor(s). The Board discovered the following deficiencies that were not causes, contributory or aggravating factors for the accident, but which may prevent future accidents if addressed:

a. The lack of a recent evaluation of bird activity within the Wash Weapons Airspace. Annex Q

b. The absence of a readily accessible and accurately predictive bird avoidance model.

LOSS OF/DAMAGE TO CLASSIFIED MATERIAL

59. The Board noted that there is no single source of data relating to the classified material fitted to Tornado ac. Following consultation with the Tornado Integrated Project Team (IPT), the Avionic and Electronic Warfare IPT and the Air Launch Munitions IPT, the Board believes that all classified material from ZG711 was recovered during the salvage operation. Annex T

OBSERVATIONS

60. The Board observes that:

a. Emergency Handling Advice in the Air Crew Manual (ACM) and Flight Crew Checklists (FCCs). The only advice available in the Tornado GR4 ACM for double engine emergencies is for Double Engine Flameout and Double TBT. The only double engine drill in the FCCs is for Double Engine Flameout whereas the Tornado F3 FCCs also include a drill for Double Engine Surge. Advice on other double engine emergencies, such as double engine mechanical failure, may not be suitable for inclusion in FCCs but the Board believes appropriate ACM advice on double engine emergencies would give crews a sound basis on which to make decisions should they be faced with such an emergency.

b. Ejection. Although ejection occurred within the safe working envelope of the Martin Baker Mk10A ejection seat, and the ac flew for a further 4 seconds before ground impact, an earlier ejection

decision would have afforded all of the crew time to adopt an appropriate ejection posture.

c. RSOs Terms Of Reference (ToRs). GASO 1G310.220 gives the following guidance regarding procedures to minimise bird strike hazard in the UK, "Low-flying activity in areas of known high bird concentrations within coastal AWRs is permitted in accordance with STCAWEWROs, provided the RSO gives an indication of low bird activity". This is at odds with the RSOs ToRs, which do not include any references to assisting aircrew with indications on bird activity. Exhibit 10 Exhibit 18

d. ADR. The ADR trace proved invaluable in determining the sequence of events and, in particular, engine behaviour after bird ingestion. However, the Tornado GR4 ADR does not record TBT data. The inclusion of TBT data would have assisted the Board in identifying, beyond any doubt, the points at which the engines were in surge. The Board considers modifying ADR input data to include TBT data could prove invaluable in identifying the precise nature of possible future engine problems. Exhibit 2 Annexes I/O/P

e. ADR Recovery. QinetiQ ADR services at Boscombe Down did outstanding work during unsociable hours to recover almost all of the HUD data from the damaged mission video tape recording. This directly contributed to the determination of the cause of the accident. Exhibit 2

f. Aircraft Recovery. The working conditions at the crash site were atrocious. Salvage operations in this environment were mentally and physically exhausting. The Salvage and Marine Operations IPT and RAF Aircraft Recovery and Transport Flight personnel were a credit to both their organisations in overcoming these conditions, showing great resolve and teamwork in achieving a positive end result. Annex J

RECOMMENDATIONS

61. The Board recommends that:

a. HQ 1 Gp investigate whether existing birdstrike reduction measures in the Wash AWRs are adequate. Annex Q

b. The appropriate authorities investigate the possibility of upgrading BAMGIS and making it compatible with TAMPA.

c. Aircrew be reminded of the need to cross coastlines, wherever possible, at a minimum height of 500ft when joining an AWR.

d. Handling Sqn examines the current advice available to aircrew on double engine emergencies.

e. Aircrew be reminded to sensibly balance attempts at saving ac

with the need to make a timely ejection decision.

f. Aircrew be reminded that the adoption of a good ejection posture may help limit the extent of their ejection injuries.

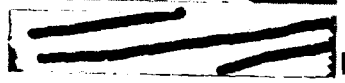
g. HQ 1 Gp investigate the conflicting orders given in GASOs and RSO ToRs regarding the assistance given to aircrew with indications on bird activity. — Exhibit 10, Exhibit 18

h. Procedures for ensuring the serviceability of the lifepreserver CO_2 cylinders be examined. — Annex K

i. Consideration be given to including TBT data on the ADR. — Annexes I/O/P

j. A list of classified material be compiled for the Tornado GR4/4A. — Annex T

President  Sqn Ldr

Members  Flt Lt

Flt Lt

Date 19 May 2007

RAF FROM 412 (ADP)
(Revised 2/97)

PART 3:

REMARKS BY STATION COMMANDER

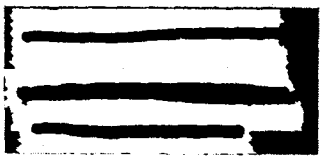
COMMENTS BY THE STATION COMMANDER

PART 3

1. I accept the findings of the Board and consider it to be well managed and thoughtful. Specifically, I would like to reinforce the recommendations that Handling Squadron review the current advice available to aircrew on double engine emergencies, and the need for timely, accurate and integrated birdstrike reduction information; I do not believe that BAMGIS, in its current format, fulfils this requirement.

2. Turning to the wider context of the accident, the enduring requirement for weaponry training at low altitude brings with it a continuing birdstrike risk, exacerbated by the current location of the vast majority of our AWRs. Clearly, mitigation of this risk can be achieved by adaptation of our attack profiles, and we need to ensure that when and where we fly at low altitude is appropriate to the training need; however, the requirement for realistic and challenging training will remain, and hence we should leave with Squadrons the scope to decide the detail and periodicity of the profiles that are flown. More broadly, I judge that this accident offers an opportunity to properly review and revitalise our AWR provision. Therefore, I believe that consideration should be given to an appropriately resourced redesign and, if necessary, relocation of our AWRs to more appropriately fulfil the training requirements of today's operational challenges.

3. Lastly, I believe that the aircrew concerned were faced with a difficult challenge that they managed well, both individually and, perhaps more importantly, as a crew. Their experience underlines the scarce time available in which to think and act when flying at low altitude, and that ejecting in time should remain our immoveable bottom-line when dealing with serious incidents of this type.



P C OSBORN
Gp Capt
OC RAF Marham

RAF FROM 412 (ADP)
(Revised 2/97)

PART 4:

REMARKS BY AIR OFFICER COMMANDING 1 GROUP

PART 4

REMARKS BY AIR OFFICER COMMANDING

1. I concur with the comments of the Station Commander. The findings of the Board reflect a comprehensive investigation and a pragmatic assessment of the factors that led to the loss of aircraft ZG711. Whilst the emergency was generally well-handled there are aspects of it that we would do well to reflect upon and from which we can draw lessons. Crucially, following the birdstrike there was nothing the crew could have done to save their critically damaged aircraft – the point at which they came to that conclusion is worth reflecting upon.

2. We seek to mitigate the risks inherent in aviation by focussed training, appropriate supervision and adherence to procedures developed from often hard-won experience. The avoidance of likely bird migration routes during periods of predicted increased activity is a key part of mission planning – actual routing, heights and speeds flown at the time of mission execution remain a key factor in risk mitigation. However, despite paying particular attention to reducing both the probability of a birdstrike and its consequences, this accident is a stark reminder that occasionally we suffer damage leading to the loss of an aircraft. Our task is to continue to mitigate the risks to the maximum extent possible commensurate with meeting mandated capability and readiness states.

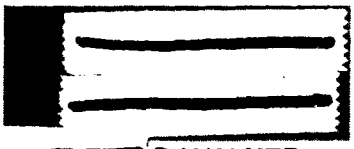
3. Study of bird migration habits suggest that an hour or so either side of high tide, sunrise and sunset represent the peak periods of birdstrike risk. That, coupled with local knowledge of the range control officers, coordination between them and local farmers' birdscaring activities and aircrew reports will continue to play a significant part in mitigating risk. A review of Air Weapon Range Orders conducted by Gp staff immediately following this accident confirmed their generic suitability. However, we must remain open to new ways of predicting and reporting bird migration patterns in the vicinity of our weapon ranges and act accordingly.

4. Regarding emergency handling and Cockpit Resource Management, I endorse the Board's recommendation that Handling Sqn should examine current advice to aircrew on double engine emergencies. Crews would benefit from a clearer understanding of the parameters beyond which a successful relight attempt and climb away would not be feasible. Meanwhile, crews will continue to take the opportunity to practice in the simulator the more unlikely but potentially catastrophic scenarios.

5. The crew of ZG711 should be applauded for guiding their aircraft away from local towns and villages whilst simultaneously trying to save a valuable aircraft. In so doing, however, the crew abandoned their stricken aircraft at low speed and very low altitude, with only some 5 seconds to go to ground impact. The aircrew instinct to save the aircraft is both understandable and

laudable; however, the need to eject in time is vital. This was an uncomfortably close call.

6. I place airborne emergencies broadly into 3 categories: minor, which can be dealt with in due course and has minimal safety consequences; major, which demands swift action and has potentially serious safety consequences; and examples such as this one: potentially catastrophic, in which abandonment is a distinct possibility despite swiftly undertaken drills. Diagnosing instantaneously that one is faced with the most serious category of emergency can be critical. Communicating that determination with clarity to a crew member and positioning the aircraft for the likelihood of abandonment emphasises the need to keep the decision point well in mind. The strap-line *eject in time* represents our hardest-won lesson of all.



11 June 2007

D WALKER
Air Vice-Marshal
Air Officer Commanding No 1 Group

RAF FROM 412 (ADP)
(Revised 2/97)

PART 5:

REMARKS BY COMMANDER IN CHIEF STRIKE COMMAND

PART 5

COMMANDER IN CHIEF'S COMMENTS

1. This accident has both re-emphasized the hazard posed by birds to low-flying aircraft and also indicated that some of the measures we use to mitigate the risk are not as effective as we would wish. It is clear from the Board's investigation that BAMGIS lacks sufficient clarity and precision, indicating only moderate bird activity within the Holbeach Range in the period of the incident (and no activity at the actual point of birdstrike). Additionally, BAMGIS data cannot be integrated into the Tornado Advanced Mission Planning Aid and, as a result, the system is not routinely used. Thus, I endorse the need to investigate its limitations and seek resolution, noting the promising work that has already been undertaken by the Met Office and DEFRA Central Science Laboratory to provide a practical, real-time birdstrike risk assessment through the use of extant weather radar systems.

2. Our main defence against migratory birds when crossing the coast at low-level is to do so at right angles and to avoid the dawn and dusk periods. Our orders also direct that coastlines should be crossed at either 1000ft[1] or 500ft[2] 'whenever possible', in order to minimise the risk of a birdstrike. I agree with the Board that crossing the coast at 1000ft to achieve 150ft for an attack run-in at Holbeach is impracticable, although I would have thought that 500ft should be achievable (given that fewer than 9% of birdstrikes suffered by RAF aircraft occur above this height supports achieving this profile). In addition, inference from the Inquiry suggests that other regulations and guidance are not rigorous. A warning in the UK Mil AIP Vol 3 reminds crews that "...the North Norfolk Coast has ***very high concentrations*** of birds. This is especially so during the period of Sep-Feb when large flocks of geese migrate from Scandinavia..." This can be allied to 1 Gp ASOs that state "Low-flying activity in areas of known high bird concentrations within coastal AWRs is permitted in accordance with Strike Command Air Weapons and Electronic Warfare Orders provided the Range Safety Officer (RSO) gives an indication of low bird activity." It seems that the RSO did not give such an indication (nor did his TORs require him to) and, importantly, the crew did not expect one. Thus, I endorse the recommendation to include more detailed clarification in the RSOs' TOR, *vis-à-vis* bird warnings, which would of course be based on timely visual observation. AWRs, of course, occupy their current locations for reasons of remoteness (coupled with the paucity of suitable land elsewhere in the UK) but I am prepared support the Stn Cdr's proposal to conduct a review of AWR provision (whilst directing that it also addresses the use of overseas AWRs).

3. Despite our attempts to mitigate the risk involved in what we do, there will always be hazards; we must be prepared for all eventualities. In this case, a multiple birdstrike led to a double engine emergency and the crew's immediate actions were faultless, gaining valuable height and turning the aircraft away from population centres (rather than towards the nearest suitable airfield – which shows awareness of the seriousness of their predicament) whilst conducting emergency procedures. Nevertheless, indications that suggested to the crew that both engines might respond to produce enough thrust to sustain flight seduced them into an ejection at 160ft and 204kts, only 4 seconds before the

[1] 1GASO 1G310.220.3
[2] UK Mil AIP Vol 3, Part 1, Section 1 01.03.11

aircraft crashed (and some 2 minutes and one second after the bird-strike). However admirable their intent to save the aircraft, the crew appeared to be very late to realise the point at which their situation was irrecoverable, and my suspicion is that the outcome for their survival might have been different had the WSO not initiated command ejection when he did (and whilst the pilot was 'heads-in'). The AOC has helpfully articulated 3 categories of emergency, with this as the worst case 'potentially catastrophic' scenario. Thankfully, for most of us, the nearest we will get to this situation is in the simulator and I therefore both urge crews to use simulator time wisely and also fully support the AOC in his recommendation to encourage crews to practise "unlikely but potentially catastrophic scenarios". I agree also that Handling Sqn be tasked to provide advice in the aircrew manual on double engine emergencies. My strong instinct is that the crew in this incident, if faced with the same situation again, would eject significantly earlier; it is important that their experience is used widely to re-publicise the 'Eject in Time' message. It is true that we can 'always get another aircraft' (or find ways to work around the loss), but the unnecessary loss of a crew (and the effect on friends and loved ones) is both tragic and irredeemable. Our people are our most valuable assets and, in order to minimise their potential loss, we must ensure that they are well prepared to deal with all eventualities.

4. This Inquiry has been diligently and exhaustively conducted and I thank the Board for its efforts and support its recommendations. The incident reinforces and underpins what is expected of us as individuals and, by extension, our duty to report whether or not the procedures/systems we are using are useful or add value – be that a call of bird activity on the range or informing the command chain that BAMGIS is not providing the necessary functionality.

5. Finally, I repeat and emphasise my commending of the crew for their highly professional actions in ensuring that the aircraft (and the jettisoned fuel tanks) crashed in a safe area.

[redacted]

SIR CLIVE LOADER
Air Chief Marshal
Commander-in-Chief

28 Sep 07