AIRCRAFT ACCIDENT REPORT 8/2010

Air Accidents Investigation Branch

Department for Transport

Report on the accident between Cessna 402C, G-EYES and Rand KR-2, G-BOLZ near Coventry Airport on 17 August 2008

This investigation was carried out in accordance with
The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996

The sole objective of the investigation of an accident or incident under these Regulations shall be the prevention of accidents and incidents. It shall not be the purpose of such an investigation to apportion blame or liability.

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This report contains facts which have been determined up to the time of publication. This information is published to inform the aviation industry and the public of the general circumstances of accidents and serious incidents.

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Air Accidents Investigation Branch
Farnborough House
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November 2010

The Right Honourable Philip Hammond
Secretary of State for Transport

Dear Secretary of State

I have the honour to submit the report on the circumstances of the accident between Cessna 402C, registration G-EYES and Rand KR-2, registration G-BOLZ near Coventry Airport on 17 August 2008.

Yours sincerely

Keith Conradi
Chief Inspector of Air Accidents

Contents

Appendices

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AAIB	Air Accidents Investigation Branch
aal	above airfield level
ADC	Aerodrome Controller
agl	above ground level
amsl	above mean sea level
ANSP	Air Navigation Service Provider
APC	Approach Controller
ATC	Air Traffic Control
ATM	Air Traffic Monitor
ATSB	Australian Transport Safety Bureau
ATSD	Air Traffic Standards Division
ATZ	Aerodrome Traffic Zone
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
cc	cubic centimetres
°C	Degrees Celsius
°M,T	Degrees magnetic, true
CTA	Control Area
DME	Distance Measuring Equipment
FAA	Federal Aviation Administration (USA)
FIO	Flight Inspection Organisation
ft	feet
GPS	Global Positioning System
hrs	hours (clock time as in 1200 hrs)
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
in	inch(es)
IRT	Instrument Rating Training
kg	kilogram(s)
km	kilometre(s)
kt	knot(s)
m	metres
MATS	Manual of Air Traffic Services
mb	millibar(s)
MHz	Megahertz
mph	miles per hour
NDB	Non-Directional radio Beacon
nm	nautical mile(s)
QNH	pressure setting to indicate elevation above mean sea level
RTF	radiotelephony
SID	Supplemental Inspection Documents
SOP	Standard Operating Procedure
SMS	Safety Management System
TCAS	Traffic alert and Collision Avoidance System
UK	United Kingdom
UTC	Co-ordinated Universal Time (the contemporary equivalent of GMT)
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional Radio Range
VRP	Visual Reporting Point

Air Accidents Investigation Branch

Aircraft Accident Report No: 8/2010 (EW/C2008/08/05)

Registered Owner and Operator:	1) Reconnaissance Ventures Limited 2) Privately owned
Aircraft Types:	1) Cessna 402C 2) Rand KR-2
Registrations:	1) G-EYES 2) G-BOLZ
Place of Accident:	Close to Coventry NDB, approximately 3.0 nm from Runway 23 threshold at Coventry Airport
Date and Time:	17 August 2008 at approximately 1036 hrs (All times in this report are UTC, unless otherwise stated)

Synopsis

The accident was notified to the Air Accidents Investigation Branch (AAIB) by Warwickshire Police shortly after it occurred; an AAIB field investigation was commenced immediately.

Cessna 402C aircraft G-EYES was engaged in flight calibration training and was making an ILS approach to Runway 23 at Coventry Airport when it was involved in a mid-air collision with a Rand KR-2 aircraft, G-BOLZ, operating in the visual circuit. The collision occurred in Class G (uncontrolled) airspace. The four occupants of G-EYES and the single occupant of G-BOLZ received fatal injuries.

The investigation identified the following primary causal factor:

> The two aircraft collided because their respective pilots either did not see the other aircraft, or did not see it in time to take effective avoiding action.

The investigation identified the following contributory factors:

1. The likelihood that the crew of G-EYES would see G-BOLZ in time to carry out effective avoiding action was reduced by the small size of G-BOLZ, its position relative to G-EYES and the high rate of closure between the aircraft.

2. Insufficient or inaccurate information was provided to the pilots, which did not assist them in fulfilling their duty to take all possible measures to avoid collisions with other aircraft.

3. The Aerodrome Controller's sequencing plan, which was based on an incomplete understanding of the nature of G-EYES' flight, was unlikely to have been successful. By the time the risk of a collision was identified, it was too late to devise an effective method of resolving the situation.

4. There were no effective measures in place to give G-EYES priority over traffic in the visual circuit.

As a result of this accident one Safety Recommendation was made.

1. Factual Information

1.1 History of the flights

1.1.1 Background information

The operator of Cessna 402C aircraft G-EYES was preparing to gain approval from the Civil Aviation Authority (CAA) to become a Flight Inspection Organisation (FIO), in order to undertake flight checks of navigation aids ('calibration flights') with this aircraft. The operator was sub-contracted to another FIO seeking to gain a capability with mobile calibration equipment in an aircraft smaller than its own. The operator had produced a Notice of Proposed Amendment to its Operations Manual detailing the procedures to be used during such flight inspections. These procedures were based on those of the contracting FIO, but were adapted to enable the role to be performed by a single pilot, with an additional safety pilot to assist with the lookout and radio operation.[1] G-EYES had been modified to perform calibration flights with the installation of a monitor on the left side of the instrument panel and role-specific electronic equipment in the cabin.

Flight training was planned to test the on-board equipment using the Instrument Landing System (ILS) at Coventry Airport and to validate the new operational procedures prior to submitting the Operations Manual amendment for approval. The CAA was aware that this training was to take place. The crew training began on 9 August 2008 and six flights were undertaken over a two-day period. The commander of the accident flight took part in the training. Further training was scheduled for 17 August 2008, the day of the accident.

1.1.2 G-BOLZ

The pilot of G-BOLZ had booked out with Coventry ATC for a private flight to the south-west, operating under Visual Flight Rules (VFR)[2]. He took off at 0919 hrs. At 1028 hrs, he called the Approach Controller (APC) at Coventry, requesting joining instructions to land, reporting that he was east abeam Leamington Spa at an altitude of 1,400 ft. He was instructed to route to the Draycott Water Visual Reporting Point (VRP) and was given the sea level altimeter pressure setting, QNH, of 1004 mb. At 1030 hrs, the pilot reported his position as two miles west of the VRP and the APC instructed him to route towards the left base for Runway 23[3].

1 The contracting organisation operated its aircraft with two crew: a Captain and a First Officer, both of whom were required to be qualified to fly the aircraft type.

2 See Appendix A for an explanation of VFR, IFR, VMC and IMC.

3 See Appendix B for an explanation of the visual circuit at Coventry Airport.

At 1032 hrs, the pilot of G-BOLZ was instructed to contact the Tower frequency. On establishing contact, the Aerodrome Controller (ADC) in the control tower instructed him to report joining left base. A PA-28 aircraft was already operating in the visual circuit. At 1033 hrs, the ADC transmitted to G-BOLZ "LIMA ZULU YOU'RE LOOKING OUT FOR A PA TWENTYEIGHT LATE DOWNWIND IN THE CIRCUIT POSITION NUMBER TWO TO HIM PLEASE". The pilot of G-BOLZ reported that he had the aircraft in sight and would position behind it.

At 1033:40 hrs, the ADC instructed the PA-28 ahead of G-BOLZ to turn onto base leg and report when on final approach. He instructed G-BOLZ to follow the PA-28 onto final approach. Figure 1 shows an image of the Air Traffic Monitor (ATM) in the control tower, presenting radar data depicting the relative positions of the aircraft around that time. The graduations on the line representing the runway extended centreline are at 1 nm spacing.

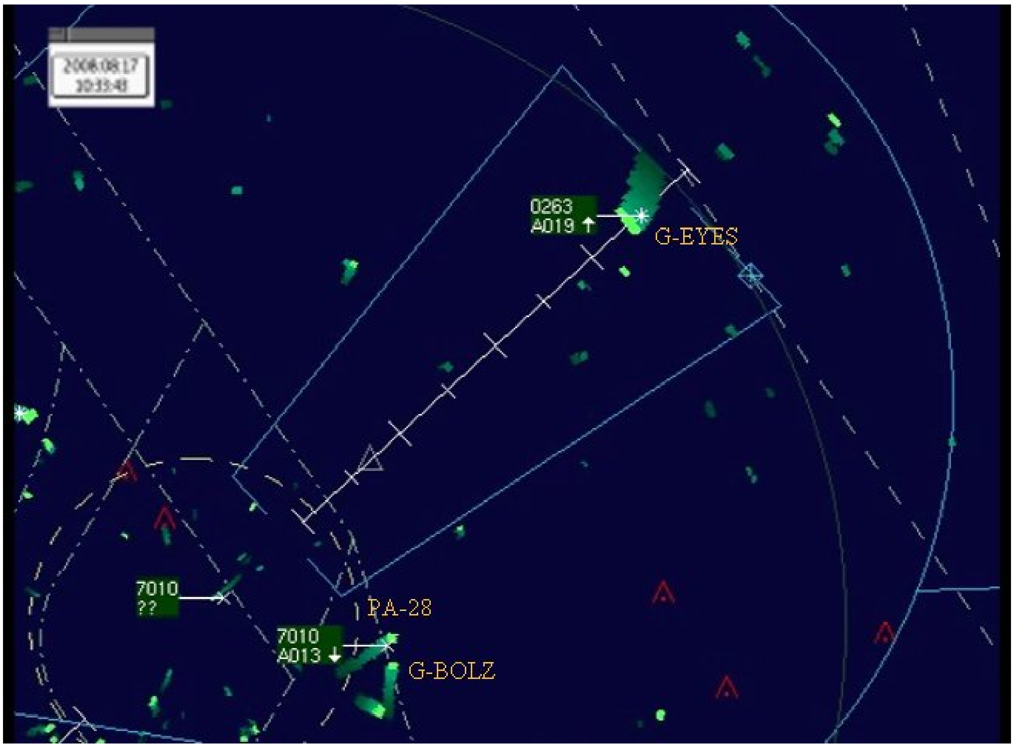


Figure 1

The ATM at 1033:43 hrs:
PA-28 about to turn onto base leg,
with G-BOLZ following

At 1035 hrs, G-BOLZ reported on left base and the ADC replied "LIMA ZULU THANK YOU YOU'RE NUMBER TWO" (Figure 2).

Figure 2

The ATM at 1035:00 hrs:
PA-28 and G-BOLZ on base leg

At 1035:30 hrs, the ADC called G-EYES to establish whether the aircraft was on his frequency. The reply confirmed that it was, that it was established on the ILS and that the crew were requesting a go-around followed by a visual circuit to land. The ADC cleared G-EYES to continue, advising that it was number three in the sequence to land (Figure 3).

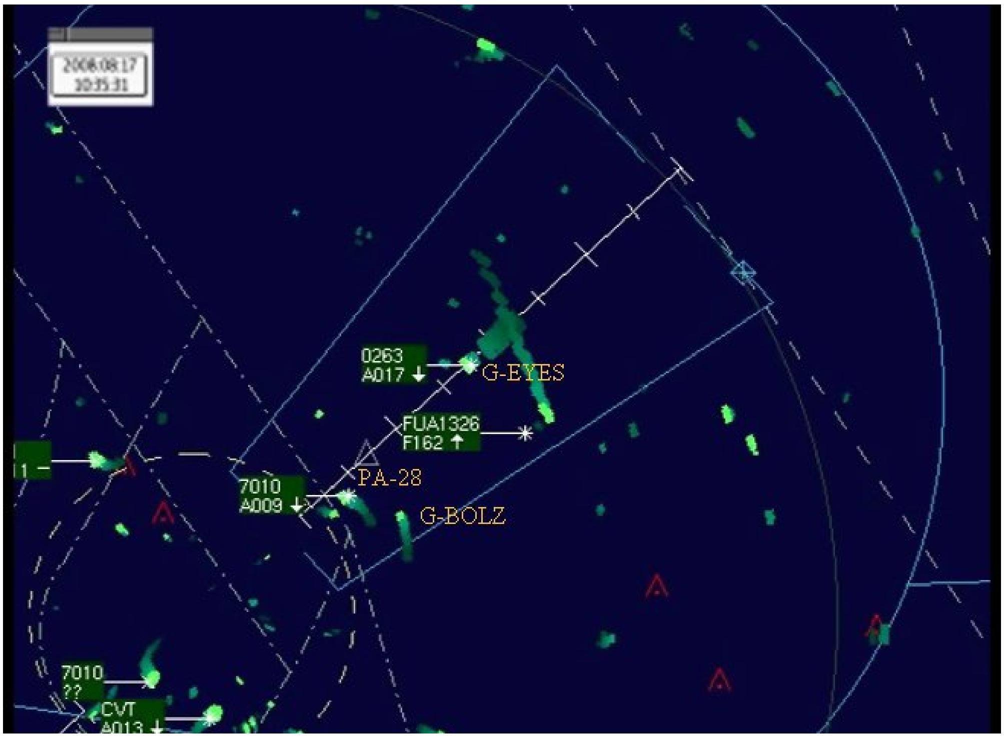


Figure 3

The ATM at 1035:31 hrs:
PA-28 turning onto final, G-BOLZ on left base,
G-EYES on 5.5 nm final

At 1036:20 hrs, the ADC transmitted "GOLF LIMA ZULU COVENTRY IF YOU CONTINUE FLYING THROUGH THE FINAL APPROACH ROUTE TOWARDS ER RIGHT BASE PLEASE". The pilot of G-BOLZ replied "GOLF LIMA ZULU"; this was his last transmission. It was estimated from timing of radio transmissions that G-BOLZ and G-EYES collided at or around 1036:32 hrs. Figure 4 shows their relative positions on the ATM display at 1036:15 hrs.

Figure 4

The ATM at 1036:15 hrs:
showing the relative positions of G-EYES and G-BOLZ
shortly before the collision

1.1.3 G-EYES

The crew of G-EYES briefed for their flight at the company operations desk at approximately 0910 hrs. The commander briefed that they would carry out several ILS approaches to become familiar with the procedures and equipment they would be using for the new ILS calibration contract. She advised that they would fly approaches at up to 160 kt and would go around from either 50 ft or 100 ft above the runway. She briefed that she would act as the safety pilot and would be responsible for radio communication after the initial takeoff clearance was received. Technical information about the equipment to be used was briefed by the crew member responsible for its use.

The crew went to board the aircraft at 0925 hrs. The commander sat in the right front seat as safety and non-handling pilot; the handling pilot sat in the left front seat. The calibration engineer sat on the left side of the mid-cabin and the passenger, who was a pilot but took no part in the flight, sat on the right side of the rear cabin.

The aircraft was assigned a callsign of 'Atlantic 403' for communication with ATC. G-EYES took off at 0954 hrs and completed two radar-vectored ILS approaches uneventfully. At 1029 hrs, it was approximately 9 nm north-east of the airport, positioning for its third approach. The safety pilot transmitted "I'D LIKE TO DO A GO-AROUND IN THE VISUAL CIRCUIT TO LAND AFTER THIS ONE". The APC asked "DO YOU WISH TO DESCEND TO OR COME DOWN TO FIVE HUNDRED FEET AGAIN?" to which the reply was "IT'D BE A HUNDRED FEET ABOVE THRESHOLD BEFORE GO-AROUND".

At 1034:30 hrs, G-EYES reported established on the localiser and was cleared to "CONTINUE APPROACH DESCEND WITH THE GLIDE". At 1035:15 hrs, G-EYES was 6 nm from touchdown and was instructed to contact the Tower controller.

At 1035:30 hrs, the ADC asked if G-EYES was on his frequency and the pilot replied "FULLY ESTABLISHED ON THE ILS AND REQUEST A GO-AROUND AT A HUNDRED FEET WITH A VISUAL CIRCUIT TO LAND". The ADC cleared G-EYES to "CONTINUE THE APPROACH YOU'RE NUMBER THREE NUMBER TWO IS JUST TURNING FINAL INSIDE THE CHARLIE TANGO". The pilot acknowledged "NUMBER THREE" but did not say whether any other traffic was in sight.

The 'Charlie Tango' denotes the Coventry Non-Directional Beacon (NDB), a radio navigation aid situated on the runway extended centreline 3.25 nm north-east of the threshold of Runway 23. It is identified by the letters 'CT' and is depicted by a triangle in Figures 1 to 4. "INSIDE THE CHARLIE TANGO" meant between the NDB and the runway threshold. At 1035:30 hrs the PA-28, number one in the sequence to land, was turning onto final approach approximately 2.6 nm from the threshold of Runway 23, which put it 6° left of G-EYES' nose. G-BOLZ, number two in sequence, was on base leg approximately 1.0 nm south-east of the NDB, putting it approximately 27° left of G-EYES' nose.

At 1036:20 hrs, the ADC instructed G-BOLZ to reposition towards right base and then transmitted to G-EYES "YOU CAN OVERHAUL THAT ER SMALL LIGHT SINGLE I'M PUTTING THROUGH THE FINAL APPROACH TO GO TOWARDS RIGHT BASE THAT YOU CAN OVERHAUL". It is believed that the collision occurred during this transmission.

1.1.4 Air Traffic Control

G-EYES was booked for 'ILS calibration work' on the Instrument Training booking sheet, kept by ATC. This was erroneously transferred to the ATC flight progress strip[4] as 'IRT' (Instrument Rating Training). The flight progress strip was pink, indicating that G-EYES was on a local flight. Just prior to departure, the crew passed their training requirements to the ADC[5] requesting radar vectors to the ILS for a ten-mile final. The approaches would be high-speed, up to 160 kt, with the landing gear retracted. There were to be three approaches followed by a crew change. The ADC issued G-EYES the departure clearance "AFTER DEPARTURE STANDARD MISSED APPROACH SQUAWK 0263" and cleared it for takeoff at 0953 hrs.

Both APCs, and the ADC on duty at the time of the accident, reported later to the CAA that G-EYES was operating under VFR.

1.1.4.1 Approach Control

There were two approach controllers involved in the events leading up to the accident; they are referred to as APC 1 and APC 2.

At 1029:20 hrs, APC 1 informed the ADC by intercom that G-BOLZ was approaching the Draycott Water VRP to join the circuit; this was acknowledged by the ADC.

At about 1030 hrs, APC 2, who was coming on shift, plugged into the radar station to monitor the traffic situation prior to receiving a handover briefing from APC 1. At 1030:40 hrs, APC 1 contacted the ADC by intercom and advised him "WHEN YOU GET THE FOUR OH THREE NEXT TIME IT'S A LOW APPROACH AND GO-AROUND INTO THE VISUAL CIRCUIT". ("FOUR OH THREE" was an abbreviation of G-EYES' callsign: 'Atlantic 403').

Coventry Airport's local procedures, contained in the Manual of Air Traffic Services (MATS) Part 2[6], state that for traffic receiving a radar service, the APC is required to inform the ADC when the traffic is at a range of 10 nm. In this case the 10 nm range check was not passed to the ADC.

Just after 1033 hrs, APC 1 instructed an aircraft waiting to join the circuit to perform a right hand orbit as the ADC was busy. He then handed over to APC 2.

4 Used by controllers to indicate, amongst other things, the type of flight a given aircraft is undertaking.

5 This was not the ADC on duty at the time of the accident. A handover of the ADC position took place after G-EYES completed its first ILS approach.

6 MATS Part 1 contains generic air traffic procedures; MATS Part 2 contains procedures specific to an aerodrome.

APC 2 contacted the ADC on the intercom to advise him of G-EYES' position and to request acceptance for the aircraft orbiting. He was unable to pass his message as the ADC was occupied communicating with five aircraft between 1034 hrs and 1035 hrs. The ADC instructed the APC 2 to wait.

After clearing G-EYES to continue its ILS approach, the APC 2 intended to transfer the aircraft to the ADC on the Tower frequency. However, two aircraft contacted him immediately afterwards and the transfer was delayed by approximately 35 seconds. After the transfer had taken place, the APC 2 turned his attention to other traffic and no longer monitored G-EYES on his radar screen.

1.1.4.2 Aerodrome Control

The ADC referred to in the rest of this report was the ADC on duty at the time of the accident. When he came on shift at 1000 hrs, he was aware that G-EYES was carrying out high-speed ILS approaches and that it had just gone around after completing one approach. Its flight progress strip was annotated 'IRT' indicating, incorrectly, that it was undertaking Instrument Rating Training. The ADC did not discover that G-EYES was undertaking ILS calibration training until after the accident.

When devising his plan for sequencing the landing traffic, the ADC assessed that G-BOLZ could be positioned ahead of G-EYES as number two to land. He expected G-BOLZ to turn onto a standard base leg, closely following the PA-28. He was aware of the positions of the PA-28, G-BOLZ and G-EYES on his ATM but, despite there being no physical obstruction to his view, he never actually saw G-BOLZ. He thought that the reason he did not acquire it visually was that it was a small white aircraft against a light background.

At 1035:30 hrs, the ADC cleared G-EYES to continue its approach, number three in the sequence to land. Between 1035:50 hrs and 1036:20 hrs, he made and received a total of seven radio transmissions, including clearing the PA-28 to perform a touch-and-go. When he returned his attention to the ATM he observed that G-BOLZ had displaced its base leg to the right, placing it in conflict with G-EYES. He instructed the pilot of G-BOLZ to reposition towards a right base. He believed that if G-BOLZ rolled out of the turn to cross the runway extended centreline, it would improve the pilot's chances of seeing G-EYES. He then transmitted the information to G-EYES about G-BOLZ's position. It is believed that the collision occurred during this transmission.

1.1.5 The collision

The collision occurred on the runway extended centreline between 1,100 and 1,200 ft amsl, approximately 3.0 nm from the threshold of Runway 23 at Coventry Airport, in Class G[7] (uncontrolled) airspace, outside the Aerodrome Traffic Zone (ATZ). It was estimated that G-BOLZ was crossing G-EYES' track at an angle of 43º and that G-EYES was overtaking G-BOLZ at a relative speed of approximately 106 kt.

G-EYES began to turn to the left immediately after the collision. Its transponder return disappeared from the ATM at 1036:47 hrs but its primary radar return remained. As the primary radar returns of the two aircraft separated, G-BOLZ's radar return remained stationary and then faded from view. G-EYES continued in a left turn for approximately 180º until its primary radar return disappeared from view at 1037:13 hrs and the aircraft descended into Binley Woods. No radio transmissions were received from either aircraft after the collision and no obvious attempt was made to recover G-EYES to straight and level flight.

1.1.6 Witnesses

1.1.6.1 Witnesses on the ground

A witness observed the accident from a position between the runway threshold and the point of collision. He stated that the two aircraft collided, with the left wing of G-EYES apparently passing directly through G-BOLZ, which then broke up, with its wreckage falling almost vertically. G-EYES then turned to its left, its angle of bank increasing up to about 60º, and began to descend. The witness reported that the aircraft was in a nose-low attitude and did not appear to be in a stalled condition.

Another witness was located 250 m from where G-EYES subsequently came to rest in Binley Woods. He heard a "loud bang", followed by an "engine spluttering noise" and then the sound of engine revving. He was unable to say whether it was one or both engines. He watched G-EYES coming towards him and recalled that it did not appear unusual to him and he could not see any smoke coming from it. He reported hearing the engine sound increasing and decreasing a number of times.

7 Further information on Class G airspace can be found in section 1.18.3 and Appendix A.

1.1.6.2 Aerodrome Controller

The ADC believed from the 'IRT' annotation on the flight progress strip that the crew of G-EYES was undertaking Instrument Rating training. He stated that, had he been aware of the true nature of the flight, he might have restricted the number of aircraft in the circuit and he would have given G-EYES a higher priority.

Because he believed G-EYES to be undertaking Instrument Rating training, the ADC decided that he could apply a local procedure[8] to his air traffic sequencing plan. He thought that using the procedure would give him more time before he had to instruct either G-BOLZ or G-EYES to break off its approach and go around.

The ADC had been controlling a solo student pilot whose standard of English seemed poor. When G-EYES made its second ILS approach, the ADC instructed the student pilot to extend the downwind leg to position behind G-EYES. He did not comply with the instruction and instead converged on the Coventry NDB, placing his aircraft in conflict with G-EYES, which was approaching the NDB from the opposite direction. The ADC found the student pilot's difficulty in comprehending standard ATC instructions difficult and distracting, but he was able to turn him away from G-EYES. On reflection, the ADC considered that G-EYES did not appear to be at a high speed on that approach and that his instruction to the student pilot to extend downwind seemed overcautious.

1.2 Injuries to persons

1.2.1 G-BOLZ

Injuries	Crew	Passengers	Others
Fatal	1	-	-
Serious	-	-	-
Minor / None	-	-	-

1.2.2 G-EYES

Injuries	Crew	Passengers	Others
Fatal	4	-	-
Serious	-	-	-
Minor / None	-	-	-

8 See paragraph 1.18.4 for an explanation of the local agreement.

1.3 Damage to aircraft

1.3.1 G-BOLZ

The aircraft was destroyed in the collision.

1.3.2 G-EYES

The aircraft sustained significant damage in the collision and on subsequent impact with trees and the ground.

1.4 Other damage

Not applicable.

1.5 Personnel information

1.5.1 Pilot of G-BOLZ

Age:	70 years	
Licence:	Private Pilot's Licence	
Proficiency check:	5 August 2008	
Medical:	Class 2, valid until 5 August 2009; corrective lenses required to be worn	
Flying experience:	Total all types:	763 hours
	Total on type:	643 hours
	Last 90 days:	7 hours
	Last 28 days:	5 hours
	Last 24 hours:	0 hours

1.5.2 Non-handling pilot and commander of G-EYES

Age:	33 years	
Licence:	Commercial Pilot's Licence	
Licence Proficiency Check:	Valid until 5 September 2009	
Instrument Rating:	Valid until 5 September 2009	
Line check:	Valid until 31 August 2009	
Medical:	Class 1, valid until 24 January 2009; corrective lenses required to be worn	
Flying experience:	Total on all types:	1,627 hours
	Total on type:	125 hours
	Last 90 days:	51 hours
	Last 28 days:	21 hours
	Last 24 hours:	0 hours

1.5.3 Handling pilot of G-EYES

Age:	28 years	
Licence:	Commercial Pilot's Licence	
Licence Proficiency Check:	Valid until 2 September 2009	
Instrument Rating:	Valid until 2 September 2009	
Line check:	Valid until 30 November 2008	
Medical:	Class 1, valid until 29 January 2009; corrective lenses required to be worn	
Flying experience:	Total on all types:	2,281 hours
	Total on type:	339 hours
	Last 90 days:	60 hours
	Last 28 days:	2 hours
	Last 24 hours:	0 hours

1.5.4 Aerodrome Controller

Age:	45 years
Licence:	Air Traffic Controller's Licence
Licence endorsement:	Valid until 19 March 2009
Experience:	Controller at the unit since August 1997

1.6 Aircraft information

1.6.1 G-BOLZ

The Rand Robinson KR-2 is a home-built, two-seat, low-wing, single-engine monoplane. It is constructed of wood, polyurethane foam, fibreglass cloth and epoxy resin and is equipped with an air-cooled Volkswagen-derived engine.

This aircraft was constructed by the owner/pilot and first flew in 1991. It was operated on a Permit to Fly, which was valid at the time of the accident. There was no record of any current defects in either the aircraft or engine log books. Prior to the accident flight, its third flight in the past 12 months, it had flown 653 hours and 40 minutes.

Wingspan	20 ft 8 in
Length	14 ft 6 in
Maximum Total Weight Authorised	400 kg
Engine	One Volkswagen-derived 1,834 cc piston engine
Maximum indicated airspeed	155 mph

Figure 5

G-BOLZ

The aircraft was not equipped with a panel-mounted VHF radio, nor a transponder. The pilot used a hand-held VHF radio connected to his headset for communication with ATC.

1.6.2 G-EYES

The Cessna 402C 'Utililiner' is a low-wing, twin-engined monoplane with a retractable landing gear. The structure is of an all-metal semi-monocoque construction. The cabin layout is convertible, allowing role changes between passenger and cargo operations.

G-EYES had recently undergone an extensive refurbishment and inspection programme in accordance with the aircraft manufacturer's Supplemental Inspection Documents (SIDs) and was released back to service on 15 July 2008. The aircraft had flown approximately 12 hours in the following month.

The aircraft held a valid Certificate of Airworthiness and Airworthiness Review Certificate. There were no significant defects recorded.

The aircraft was equipped with integrated VHF communication radios and a transponder[9] capable of transmitting in Modes A, C and S.

9 When interrogated by ATC radar, the transponder transmits data which can be decoded by ATC radar to display specific information on the aircraft, including its altitude, on the radar screen.

Wingspan	44 ft 1½ in
Length	36 ft 4½ in
Maximum Total Weight Authorised	3,107 kg
Engines	Two Continental TSIO-520-VB piston engines
Maximum indicated airspeed	266 mph

Figure 6

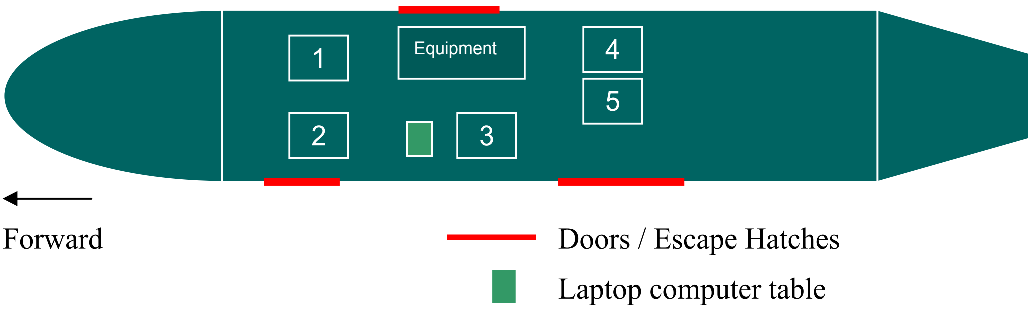
G-EYES

The interior was configured for the ILS calibration role and seats were provided for two pilots, a calibration engineer and two additional persons. The pilots' seats were fitted with car-type lap belts with a single shoulder strap; the calibration engineer's seat was equipped with a lap belt, crotch strap and two shoulder straps and the two remaining seats were equipped with lap belts only. The general cabin layout is shown in Figure 7. Calibration equipment was mounted on the floor tracks on the right side of the cabin and an additional monitor was mounted on the left side of the instrument panel (Figure 8). A table was positioned in front of the calibration engineer's seat for the use of a laptop computer.

The design work for the modification (reference 'TEN 556') to install additional calibration equipment was conducted by a CAA-approved design organisation and this work considered the position of the additional monitor. The design compliance report stated:

'Pilot vision has been considered and complied with by installing the monitor at a position where the view of the pilot was not impeded. It is also established that the clear view in rain and icing conditions is not affected and that the view through the opening window is also unaffected by this installation.'

This was carried out by the design engineer sitting in the pilot's seat and assessing the view. Pilots from the operator were also consulted to ensure that they were satisfied that the monitor did not significantly impair the view out of the cockpit.



Crew seating positions:
1 = Commander, 2 = Pilot, 3 = Calibration Engineer, 4 = Observing pilot, 5 = Vacant

Figure 7

G-EYES cabin layout

Figure 8

Calibration equipment, pilot's monitor

The design work also gave consideration to the installation of the laptop table but it was not included in the modification approval, as its installed location had yet to be determined. However, installation instructions (reference TEN 556/10.1) were supplied to the operator.

1.7 Meteorological information

The weather at Coventry Airport at 1020 hrs was: surface wind 250°/9 kt, varying between 210° and 280°; visibility 10 km or more; scattered cloud at 2,000 ft; temperature 17°C, dew point 11°C; and QNH of 1004 mb. Other information from the Met Office gave the winds at different heights above the airfield at 1035 hrs as:

2,000 ft	240°/17 kt
1,200 ft	235°/17 kt
1,000 ft	230°/15 kt
700 ft	230°/14 kt

1.8 Aids to navigation

Coventry Airport is equipped with an ILS on Runway 23 transmitting on a frequency of 109.75 MHz, with an inbound localiser course of 230°(M). It also has an NDB transmitting on 363.5 MHz, located 3.25 nm from the runway threshold on the runway extended centreline.

1.9 Communications

Records were available of transmissions made on the frequencies used by the approach controllers and the aerodrome controller. Records were also available of communications made on the intercom between the ADC and the APC.

1.10 Aerodrome information

Coventry Airport is situated 3 nm south-south-east of the city of Coventry and is at an elevation of 267 ft. The Aerodrome Traffic Zone (ATZ) is the airspace within a circle of radius 2.5 nm, centred on Runway 05/23, with a vertical limit 2,000 ft above the aerodrome level. The ATZ is partly within the Class D airspace of Birmingham Control Area (CTA), the base of which is 1,500 ft amsl to the west and south, and 2,000 ft amsl to the north and east of Coventry Airport. The remainder of the ATZ, including the part that contains the visual circuit and instrument approach path, is within Class G airspace. The collision occurred outside the ATZ within Class G airspace.

1.11 Recorded data

1.11.1 G-BOLZ

A GPS receiver was recovered from G-BOLZ but no tracks were recorded for any flights during 2008.

1.11.2 G-EYES

1.11.2.1 GPS/radio/navigation information

A Garmin GNS 430 panel-mounted combined GPS receiver and communications unit was recovered from the aircraft. The GPS function was inoperative and did not record any data on the accident flight. The active communications channel was on the Tower frequency of 118.175 MHz and the standby frequency was selected to 119.250 MHz. The frequency set for the radio navigation aids was 109.75 MHz, the Coventry localizer, with a standby frequency of 116.40 MHz, which is the Daventry VOR/DME, as shown on the Coventry instrument approach chart for Runway 23.

A portable GPS receiver, a Garmin GPSMAP 495, was also recovered from the aircraft. This provided reliable flightpath information for the entire accident flight. The recording consisted of time-stamped position information, recorded with a lower sample rate during steady flight and a higher rate during manoeuvres. The GPS recording of the accident flight commenced at 0932 hrs. Three circuits at Coventry were recorded. The recording ended at 1036:24 hrs, during the third approach, with the time interval between samples varying between 10 and 13 seconds.

1.11.2.2 ILS calibration equipment

The ILS calibration equipment fitted to G-EYES was operated via a 'ruggedized' laptop. Its hard drive was analysed by forensic science experts. According to the software supplier, in order to save the data for a calibration run, the user was required to stop the data-gathering process and then save the data to the computer's hard drive. Data files for the first two approaches were recovered, but none were recovered for the third approach. At the time of the collision, the aircraft had not reached the point on the approach at which the data gathering had ceased on the previous two approaches. Whilst there was no evidence recorded in the laptop as to whether or not data were being gathered on the third approach, the forensic analysis showed that the laptop was switched on at the time of the accident and that it went into hibernation mode after the battery became depleted, some time after the aircraft had come to rest.

1.11.3 Radar

There were two types of radar in use: primary and secondary. Primary radar detects aircraft from the reflection of radio waves off an aircraft structure. Secondary radar installations send radio signals to interrogate a transponder unit fitted to aircraft. The aircraft transponder returns electronic messages containing a four-digit identification code and, optionally, altitude and other flight information. G-EYES was equipped with a transponder unit, but G-BOLZ was not, nor was it required to be. The Clee Hill secondary radar recorded valid position and altitude information for G-EYES. The last secondary radar return recorded for G-EYES was at 1036:32 hrs. One more primary radar return was recorded by Clee Hill eight seconds later, indicating that the transponder capability had been lost in the period between radar sweeps. The last transmitted altitude information from G-EYES corresponded to an aircraft height of 800 to 900 ft agl.

The radar display provided to the controllers at Coventry was an amalgamation of the Coventry primary radar data and secondary radar data from Clee Hill. The primary radar data was not recorded (and was not required to be), but the combined display images were recorded as part of an engineering project. These images show that the collision occurred between 1036:30 hrs and 1036:36 hrs. Although other sources of radar data were available, the Coventry radar recording was used for the analysis as it had captured G-EYES, G-BOLZ and the PA-28.

Figures 9 and 10 were generated from the amalgamation of the recorded data discussed above and show the tracks of G-BOLZ, G-EYES and the PA-28. Figure 10 shows that the bearing of G-BOLZ relative to the nose of G-EYES remained almost constant for approximately three minutes before the collision.

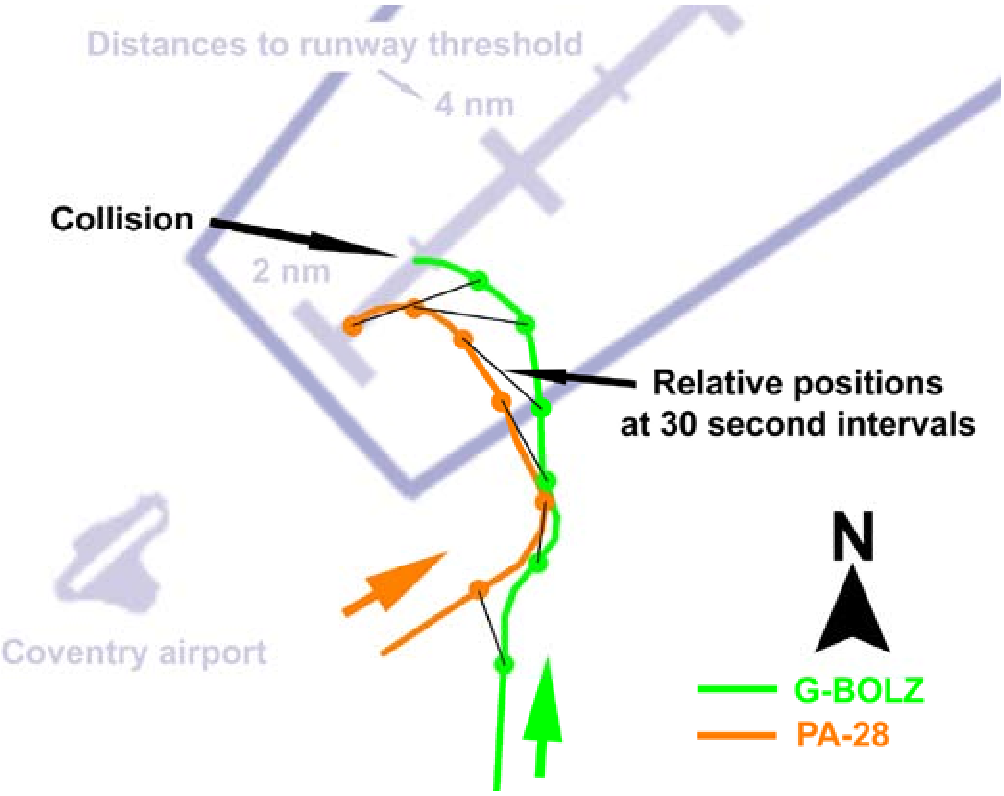


Figure 9

Separation between G-BOLZ and the PA-28

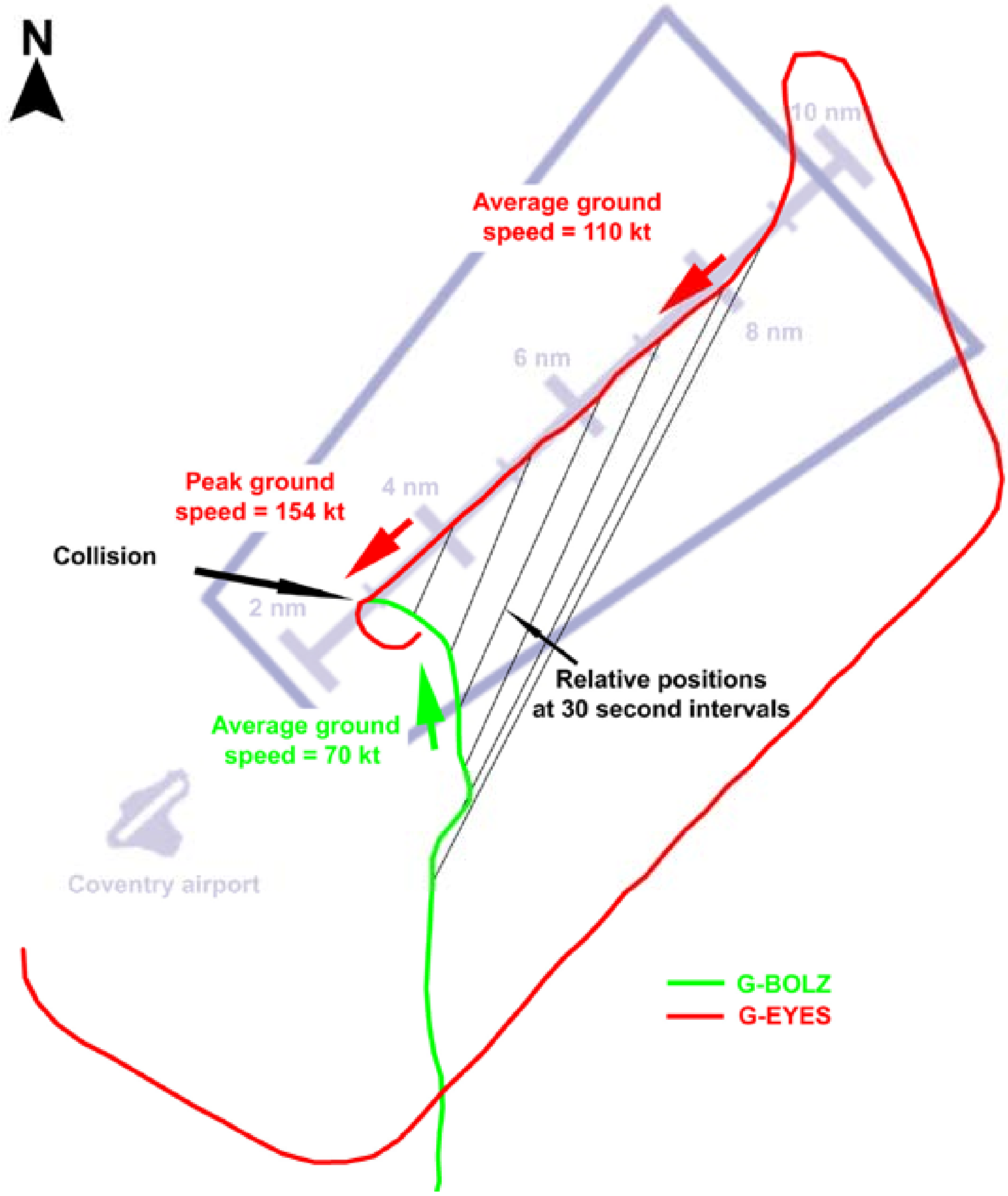


Figure 10

Tracks and speeds of G-BOLZ and G-EYES

1.11.4 A comparison of the last two approaches of G-EYES

Figure 11 shows a comparison between the altitude and groundspeed of G-EYES on its second and third approaches. The aircraft began its third approach approximately 8 kt slower than its second approach but accelerated and achieved the same speed just as it began to descend. During the descent on the third approach, G-EYES was faster than on the second approach by up to 6 kt. G-EYES gained approximately 30 kt during the descent of the second approach and approximately 45 kt during the descent preceding the accident.

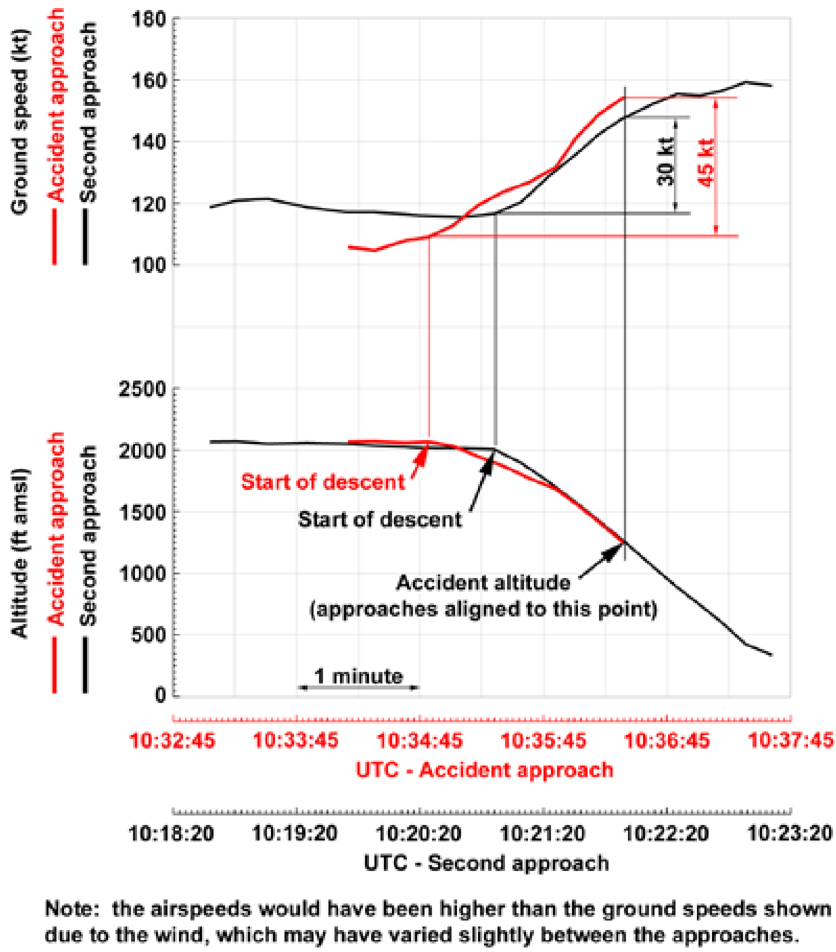


Figure 11

Comparison of G-EYES' last two approaches

1.12 Wreckage and impact information

1.12.1 G-BOLZ

The wreckage of G-BOLZ was located in fields to the south of Coombe Abbey, on the eastern outskirts of the city of Coventry. The engine, fin, rudder, left tailplane and left wing were the only parts of the aircraft found largely intact. Most of the remaining smaller and lighter parts were found along a trail approximately 1 km long and 100 m wide, aligned with the wind direction (Figure 12).

Copyright Google Earth™ mapping service/Infoterra Ltd & Bluesky

Figure 12

Wreckage locations

A number of parts from G-EYES were found amongst the wreckage of G-BOLZ (Figure 13). These consisted of: the left rear nose baggage bay door, a large portion of the pilot's escape hatch and its frame, parts of the windscreen and side window transparencies, the sun visors from both windscreens, the ILS calibration monitor screen from the left side of the instrument panel, aerials from the top of the fuselage and the left side of the fin, and most of the passenger escape hatch from the right side of the fuselage. Various papers, charts and pieces of interior trim from G-EYES were also found in the vicinity.

Figure 13

Parts of G-EYES found with the wreckage of G-BOLZ

1.12.2 G-EYES

The wreckage of G-EYES was located in Binley Woods, approximately 2 km south-south-east of Coombe Abbey. The aircraft was largely intact, apart from those items found with the wreckage of G-BOLZ.

The aircraft came to rest inverted. The wreckage trail extended approximately 150 m through trees, where several large tree trunks had been severed and a number of branches had detached. The leading edges of the wings and tailplanes had suffered substantial damage, largely as a result of passing through the trees. Both wingtips were detached and both wingtip landing lights were in the retracted (ie OFF) position. The right engine had struck a tree and had detached shortly before the aircraft came to rest. Both propellers had detached from, and were found close to, their respective engines. The tailplane and fin remained attached and the fin supported the rear of the fuselage clear of the ground. The forward section of the cabin roof was crushed towards the floor by the ground impact, compromising the available survival space in the cabin.

Significant collision damage was visible on the left side of the forward fuselage. The parts found with the wreckage of G-BOLZ were indicative of the extent of this damage. A number of pieces of wreckage from G-BOLZ were found amongst the wreckage of G-EYES; some were inside the cabin. These consisted of a substantial number of parts of the leading edge of G-BOLZ's right wing and small parts of forward fuselage structure.

1.12.3 General

The wreckages of both aircraft were examined in detail.

The larger parts of G-BOLZ were laid out to partially reconstruct the aircraft. Scrape marks and paint transfer from G-EYES were visible on the right wingtip, angled at approximately 45° to the longitudinal axis of the aircraft. Several propeller cut lines, also aligned at approximately 45°, were visible on the right aileron and the trailing edge of the right wing. The top of the fuselage, aft of the cockpit, exhibited blue paint transfer and black deposits matching the rubber de-icing boot fitted to the leading edge of G-EYES' tail fin.

G-EYES' electrical distribution system, located to the left of the pilot on the cockpit left side wall, was substantially disrupted and several circuit breakers had tripped.

The control systems of both aircraft were examined for integrity and, as far as was possible, freedom from obstruction. No pre-existing control system abnormalities were found on either aircraft. The engines from both aircraft were also inspected. No evidence of any pre-accident defects was found.

1.13 Medical and pathological information

The post-mortem medical examinations were carried out by a consultant aviation pathologist.

It was concluded that the pilot of G-BOLZ died of multiple injuries sustained during the collision and subsequent ground impact.

The handling pilot, in the left seat of G-EYES, probably died from multiple injuries sustained at the time of the collision.

Evidence suggested that the commander in the right seat was not killed in the collision, although she suffered minor head injuries which may have been sufficient to render her unconscious. It appeared that she died from postural asphyxia due to the inverted post-ground impact attitude of the aircraft and the reduction of the survival space due to the crush damage to the cabin roof. Police body recovery personnel noted that contact lenses were present when she was removed from the aircraft.

The calibration engineer died of a head injury. It was impossible to ascertain whether this injury was caused by an object within G-EYES or by intrusion into the cockpit by part of G-BOLZ. His seat was equipped with a lap strap, crotch strap and shoulder harnesses, but they were found unfastened. It was likely that he died at the time of sustaining the head injury.

The pilot in the rear of G-EYES sustained a head injury which could have rendered him unconscious. He died of postural asphyxia due to the inverted attitude of the aircraft and the reduction of the survival space due to the crush damage to the cabin roof.

There was no evidence of significant pre-existing natural disease in the pilots of G-BOLZ or G-EYES which could have caused or contributed to the accident. Toxicology tests revealed no evidence in the bodies of the pilots of alcohol, or levels of drugs that could affect performance.

1.14 Fire

There was no evidence of fire on either aircraft.

1.15 Survival aspects

1.15.1 Search and Rescue

A police and an air ambulance helicopter were operating locally and arrived at the scene within a few minutes of the collision. The wreckage and the pilot of G-BOLZ were located quickly in open countryside. G-EYES was located a few minutes later after a break in the tree canopy was identified that allowed the wreckage to be seen from the air.

1.15.2 Survivability

The collision was not considered survivable for the pilot of G-BOLZ, the pilot in the left seat of G-EYES, or the calibration engineer.

The pilot in the right seat and the passenger in G-EYES survived the collision, but were probably incapacitated to some degree. After G-EYES came to rest, its inverted attitude and the crush damage to the cabin roof would probably have prevented evacuation, even if the surviving occupants had not been incapacitated.

1.16 Tests and research

1.16.1 Visual acquisition of G-BOLZ, G-EYES and the PA-28

1.16.1.1 Visual air-to-air acquisition

The Australian Transport Safety Bureau (ATSB) examined the issue of visual acuity in their research report, 'Limitations of the See-and-Avoid Principle'[10], published in April 1991. The report stated that:

> *'acuity in daylight is dramatically reduced away from the direct line of sight. [An object will] generally be first detected in peripheral vision but must be fixated on the fovea[11] before identification can begin. Targets frequently appear in the corner of the eye where acuity can be reduced by factors such as vibration and fatigue.'*

The report considered the angular size that the retinal image of an aircraft would have to be before it was identifiable as an aircraft and suggested a threshold of 0.2º up to approximately 0.5º in more realistic sub-optimal conditions.

The effectiveness of visual air-to-air acquisition is also dependent on the contrast of an aircraft with its background[12]. Increased contrast improves visual acquisition but contrast degrades exponentially with visual range. If contrast reduces to approximately 5%, the target disappears.

1.16.1.2 The visibility of G-BOLZ when viewed from G-EYES

It was not possible to account for contrast during this investigation and so the following analysis considers only the size of the target. The results should therefore be considered indicative, rather than definitive.

G-BOLZ remained on an almost constant bearing of approximately 27º to the left of G-EYES[13] for approximately three minutes prior to the collision. Its relative position as viewed from G-EYES would therefore have remained almost constant during that period (Figure 10). The human eye will often detect an object by its relative movement and then bring it into focus for identification. The lack of relative movement in this case would have made it difficult for the crew of G-EYES to detect G-BOLZ in the absence of information with which to narrow their search.

10 ISBN 0 642 16089 9 Reprinted November 2004
11 The fovea is the central part of the retina.
12 Project Report ATC-152. Unalerted air-to-air acquisition. J. W. Andrews 26 November 1991.
13 Assuming G-EYES had a drift angle of 1º right to maintain the localiser in the wind conditions.

When viewed from G-EYES, the aspect and apparent size of G-BOLZ would have varied as the latter turned towards the final approach[14]. G-BOLZ's angular size was estimated[15] at specific times leading up to the collision; the results are shown in Table 1.

TIME	TIME TO COLLISION (s)	RANGE (nm)	ANGULAR SIZE (º)
1036:13	19	0.69	0.19
1036:18	14	0.54	0.25
1036:23	9	0.40	0.33
1036:26	6	0.26	0.53

Table 1

Angular size of G-BOLZ when viewed from G-EYES

It is estimated that the collision occurred at approximately 1036:32 hrs. According to the ATSB report, the results suggest that in ideal conditions G-BOLZ might have been visible to the crew of G-EYES approximately 19 seconds before the collision. In more realistic conditions, G-BOLZ should have been visible approximately 7 seconds before the collision.

1.16.1.3 Angular position of G-BOLZ relative to G-EYES

The altitude of G-EYES was derived from its transponder's Mode C return. G-BOLZ was not transponder-equipped and thus there was no direct evidence of its altitude. The collision occurred between 1,100 and 1,200 ft amsl. Working on the assumption that G-BOLZ was between 1,300 and 1,200 ft amsl on the base leg, the angular position of G-BOLZ relative to G-EYES was estimated. The results are presented in Table 2

14 The aspect of G-BOLZ relative to G-EYES was estimated from the ATM to an accuracy of ± 5º.
15 The angular size was calculated using the length of G-BOLZ, which was 14.5 ft.

TIME	RANGE (nm)	ANGLE BELOW THE HORIZON (°)	ANGLE LEFT OF THE NOSE (°)
1035:00	4.00	1.7	27
1035:46	1.84	1.5	27
1036:13	0.69	2.0	27
1036:26	0.26	1.8	27

Table 2

The position of G-BOLZ relative to G-EYES

The AAIB undertook an investigation of the field of view from the cockpit of an aircraft similar to G-EYES. An assessment was made from each pilot's seat to find where G-BOLZ would have appeared on the windscreen at the data points in Table 2. The assessment used representative eye positions which could not take account of the actual orientation and level of the pilots' heads, and thus the results are only best estimates. The results suggested that the view towards G-BOLZ from the left seat was probably unobstructed. However, when viewed from the right seat, G-BOLZ would probably have been located behind, or slightly to the left of, the windscreen central pillar in the area between the compass mounting and the coaming (Figure 14). (Note that the size of the circle is not intended to be representative of the size of G-BOLZ.)

Figure 14

The estimated location of G-BOLZ when viewed from
the right seat of G-EYES

1.16.1.4 The visibility of G-EYES when viewed from G-BOLZ

The angle subtended at the eyes of the pilot of G-BOLZ by the 44 ft wingspan of G-EYES was calculated at different ranges and the results are presented in Table 3. The results suggest that, in ideal conditions, G-EYES might have been visible from G-BOLZ at a range of 1.84 nm, some 46 seconds before the collision. More realistically, G-EYES would have been theoretically visible at 0.74 nm, some 19 seconds before the collision.

TIME	TIME TO COLLISION (s)	RANGE (nm)	ANGULAR SIZE (°)
1035:46	46	1.84	0.2
1036:13	19	0.74	0.5
1036:18	14	0.54	0.7
1036:23	9	0.40	0.9
1036:26	6	0.26	1.4

Table 3

Angular size of G-EYES when viewed from G-BOLZ

1.16.1.5 Angular position of G-EYES relative to G-BOLZ

The relative bearing between G-BOLZ's fuselage longitudinal axis and G-EYES was calculated for specific times. The results are presented in Table 4.

TIME	HEADING OF G-BOLZ (°M)	RELATIVE BEARING OF G-EYES (° RIGHT)
1035:00	347	37
1035:46	323	61
1035:58	306	78
1036:13	299	85
1036:23	292	92
1036:26	284	100
1036:31	263	121

Table 4

Relative bearing from G-BOLZ to G-EYES

When viewed from the left seat of a Rand KR-2 cockpit[16], the leading edge of the right wingtip is approximately 79°, and the trailing edge approximately 94°, away from straight ahead. It was estimated that G-EYES would have appeared somewhere along the wingtip between 1036:00 hrs and 1036:24 hrs. During that time, G-BOLZ's heading changed, on average, at about 0.8° per second corresponding to an average angle of bank of approximately 3º. It was unlikely, therefore, that G-EYES was hidden from view by G-BOLZ's wing. During G-BOLZ's turn onto the final approach, G-EYES was likely to have been visible behind the trailing edge of G-BOLZ's right wing.

1.16.1.6 The visibility of the PA-28 when viewed from G-EYES

At 1035:31 hrs, when G-EYES was at 5.5 nm on the ILS and the crew were given their sequence to land, its range to the PA-28 was 2.8 nm. At this range, the 35 ft wingspan of the PA-28 would have had an angular size of 0.1°, suggesting that it would not have been visible from G-EYES. The PA-28 could have become visible in ideal conditions when its angular size increased to 0.2°, which would have been at a range of 1.65 nm. This occurred at approximately 1036:19 hrs, 13 seconds before the collision.

1.17 Organisational and management information

1.17.1 The Operations Manual amendment

The operator of G-EYES based its proposed procedures for ILS calibration flights on the contracting company's own procedures. The commander of G-EYES on the accident flight had the lead role in developing the operator's procedures and had prepared the amendment to the Operations Manual. The flights were to be operated using single-pilot Standard Operating Procedures (SOPs), to provide commonality with the company's other operations, but with the addition of a safety pilot.

On ILS calibration flights only, the amendment stated that the safety pilot would be:

> *'responsible for lookout, calibration radio calls and pilot's log-keeping as well as altimeter checks and height calls to the commander on the approach. All other duties will be carried out by the commander to single pilot SOPs.'*

16 Measurements were taken from a plan view.

During single-pilot operations, the commander would be the handling pilot and seated in the left seat. However, on the accident flight the commander sat in the right seat and was performing the duties of the safety pilot, in addition to the pilot training task.

1.17.2 Aircraft lighting

G-EYES was equipped with retractable landing lights which could be used up to the landing gear limiting speed of 180 kt. The operator considered that the aircraft's performance following an engine failure would be degraded with the lights extended, and they could become a cause of disorientation if the aircraft entered cloud. Consequently, their use was not included in the proposed procedure for ILS calibration flights.

Since the accident, the operator has changed its procedures for all operations to allow the use of landing lights, if required. The procedures following an engine failure include the requirement to retract the lights, if extended.

1.17.3 Operator's Safety Management System

The operator's Safety Management System (SMS), described in the company's written procedures, defined safety management as:

> *'the comprehensive identification, assessment and control of the risks associated with flight operations, ground operations, aircraft maintenance and other activities carried out by the Company's staff, in order to achieve the highest level of safety performance.'*

The safety management team included the Chairman and Group Managing Director, who was the Accountable Manager, the Flight Operations Director and the Chief Pilot.

The SMS procedures stated that:

> *'if a new activity is under consideration, or a change is being made to current activities, a risk analysis will be carried out.'*

It was expected that the team member closest to the activity would have:

> *'assessed the risk and produced a risk analysis.'*

According to the SMS, the risk analysis would be discussed at the operator's monthly safety meeting.

The operator stated that discussions took place regarding the operational aspects of the proposed ILS calibration flights and that it was decided that 160 kt would be an appropriate approach speed to simulate airliners flying an ILS approach. Airliners are often required to maintain 160 kt until four nautical miles from touchdown for sequencing at busy airports. They are usually free to slow to their final approach speed, typically 120 to 130 kt, when inside four nautical miles. The operator considered that to decelerate while calibrating would destabilise the approach and so it was decided to fly at up to 160 kt until over the runway threshold. Aircraft configuration and power settings were discussed, as were the higher than usual speed and momentum that would be features of the go-around. It was also decided that ATC would be informed on the radio before departure about the higher speed of approach. There was no evidence of the operator having discussed the planned calibration training activity with Coventry ATC management in advance.

It was decided to conduct the flights under Instrument Flight Rules (IFR), a decision which was specifically aimed at giving the ILS traffic protection from the visual circuit traffic. The operator believed that circuit traffic could be told to position behind the ILS traffic but an aircraft on an ILS approach could not be told to position behind circuit traffic.

No risk assessment document was produced and no minutes of relevant discussions at the monthly safety meetings were seen by the AAIB. However, the operator believed that the process of developing procedures to the point of submission to the CAA constituted a "detailed study of the operating environment" and an "assessment of the appropriate operating methodology".

1.18 Additional information

1.18.1 Report by the CAA Air Traffic Standards Division (ATSD)

1.18.1.1 Introduction

The CAA ATSD carried out an investigation into the air traffic service provided to the aircraft involved in this accident. The investigation included information from ATC reports, RTF transcripts, radar recordings and interviews with the controllers concerned. A précis of the report is provided in sections 1.18.1.2 and 1.18.1.3.

1.18.1.2 ATSD report findings

All ATC equipment relevant to the task was serviceable at the time. Both APC 1 and APC 2 reported their respective workloads as light to medium. The ADC reported his workload as medium to high. All controllers held relevant Certificates of Competence for their respective roles.

Although G-EYES was not issued with a VFR clearance, the flight was treated by ATC as being operated under VFR.

Coventry Airport's Manual of Air Traffic Services (MATS) Part 2 contained local instructions regarding procedures in operation at the airport. The Aerodrome Control section considered traffic arriving at the airport and stated:

> *'if the inbound (VFR or IFR)[aircraft] is receiving a radar service from Coventry Radar, the Air Controller (i.e. ADC) will be advised of the aircraft's position on first contact. A 10 nm range check will then be passed to ADC.'*

No 10 nm range check was passed regarding G-EYES but the ADC commented at interview that he was aware of its position from the ATM.

Civil Aviation Publication (CAP) 493, The Manual of Air Traffic Services (MATS) Part 1, contains instructions and guidance to controllers providing Air Traffic Services. MATS Part 1 states in Section 3 that:

> *'Approach Control must ensure that VFR flights are transferred in sufficient time for Aerodrome Control to pass additional information in respect of local traffic.'*

MATS Part 2 stated in the Aerodrome Section that, for VFR and IFR traffic:

> *'if the landing aircraft is not transferred to the Tower frequency by 4 nm from touchdown, APC will request a landing clearance.'*

G-EYES was transferred by 5.8 nm, approximately 30 seconds later than APC 2 intended but within the limit given in MATS Part 2.

The ADC was aware of the positions of the three aircraft on approach and they were under his control. MATS Part 2 stated that:

> *'ADC is responsible for integrating visual circuit traffic with aircraft positioned by APC.'*

The ADC assessed that G-EYES would fit in behind G-BOLZ in the traffic sequence but he intended to monitor the situation and turn G-EYES away from its approach if necessary. On its previous approach, G-EYES had appeared to fly more slowly than the ADC had expected and he thought this might have led him subsequently to underestimate the speed of its next approach.

In the CAA's assessment, it was unlikely that G-EYES would have been able to continue its descent to 100 ft at the threshold as the PA-28 would probably have still been on the runway after landing thereby preventing the low go-around clearance to be issued. MATS Part 1 states in Section 2 that:

> *'if the runway in use is occupied by aircraft or vehicles, an approaching aircraft shall not be cleared to carry out a missed approach procedure which includes a descent below 400ft above the threshold elevation. The runway in use shall be kept clear of aircraft and vehicles if an approaching aircraft is likely to descend below 400ft above the threshold elevation.'*

The report noted that the relative positions of G-EYES and G-BOLZ were assessed using radar information which gave positions that were delayed slightly from the actual positions.

1.18.1.3 ATSD Human factors analysis

The CAA report included an assessment of the human factors relating to the ATC personnel involved, which are presented as follows:

Communication

The APC 2 did not know whether or not a 10 nm call had been made to ADC about G-EYES, but was told that the ADC was aware of the crew's intentions. He assumed this information must have been passed along with the 10 nm check. In fact, no 10 nm call had been made, but APC 1 was unaware at the time of his omission. The ADC stated that this omission made no difference to his situational awareness.

The information contained on the flight progress strip for G-EYES was potentially confusing. The flight progress strip showed 'IRT' whereas the training sheet showed 'ILS calibration work'.

Workload

The ADC had been at his position for just over 30 minutes when the accident occurred and he felt the traffic was "starting to build". In retrospect, he believed he significantly underestimated the workload caused by the foreign solo student and it took up a significant part of his capacity. His ability to deal with other aircraft under his control was, therefore, compromised to an extent. High workload can be a source of stress which, in turn, can have an impact on planning, decision-making and subsequent actions.

Planning

The ADC had to integrate traffic in the circuit with traffic joining the circuit. His task was to formulate a number of small plans related to specific aircraft and then combine those plans into an integrated whole. However, as the situation was dynamic, he had to reassess his planning regularly and adjust it as necessary. Individuals often find this reassessment difficult to achieve, especially when working under stress. A plan, once formulated, reduces stress since it provides a way ahead and allows the individual to devote attention to other tasks. However, the tendency is to adhere to a plan even when circumstances mean it is no longer workable. Individuals often find it difficult to distance themselves mentally from their own plan to assess whether it is still viable, particularly in times of stress.

The ADC had decided over two minutes before G-EYES came onto his frequency that G-BOLZ was to be number two in sequence to land after the PA-28. At 1035 hrs, when G-BOLZ was established on base leg, he reconfirmed the sequence. When he told the crew of G-EYES that they were number three in sequence, he believed his plan was satisfactory and turned his attention to other aircraft under his control.

Decision-making

The ADC did not perceive any potential conflict with G-EYES until he saw that the pilot of G-BOLZ had extended the base leg. When he realised his original plan was no longer viable, he felt he had to make a decision quickly and instructed G-BOLZ to reposition onto a right base.

Subsequent analysis of the recording of the ATM indicated that the ADC's plan was not achievable due to the proximity of the aircraft and the high speed of G-EYES on the approach.

The CAA report concluded that, from an ATC standpoint, the accident was not the result of a single factor but rather an accumulation of elements.

1.18.2 Uncontrolled airspace

Class G airspace is uncontrolled airspace that allows pilots a high degree of freedom in flight. Pilots determine the appropriate air traffic service depending on the phase and conditions of flight and request the desired service from ATC. Instructions issued by controllers to pilots operating outside controlled airspace are advisory, not mandatory. Having requested a service, however, pilots are expected to comply with ATC instructions unless they inform the controller otherwise.

A flight arriving at an aerodrome located in Class G airspace may be given an Approach Control Service. The service will be given from the moment the aircraft places itself under Approach Control until it is transferred to Aerodrome Control. There is no legal requirement for pilots to comply with instructions issued by Approach Control unless they are within the ATZ. This accident occurred outside the ATZ.

Regardless of the ATC service being provided, when flying in VMC in Class G airspace pilots must take all possible measures to avoid collisions with other aircraft. Pilots are expected to use the see-and-avoid principle to acquire visually other aircraft that may come into close proximity and maintain separation from them. This principle is a fundamental concept in aviation that requires a thorough lookout to be maintained at all times.

The see-and-avoid principle may be augmented by the provision, by ATC, of additional information on other traffic in the vicinity.

1.18.3 Manual of Air Traffic Services Part 1

Unless otherwise stated, references to MATS Part 1 in this report refer to the document dated 22 November 2007.

1.18.3.1 Separation Standards

Air traffic management procedures make provision for the horizontal or vertical separation of air traffic. Separation is not provided between all aircraft at all times, however, and its provision depends on the class of airspace and the flight rules under which the aircraft are operating. Section 1 of MATS Part 1 details the separation that will be provided and it states that:

> *'standard vertical or horizontal separation shall be provided, unless otherwise specified, between IFR flights in Class G airspace being provided with a service by an Approach Control unit.'*

ATC is not required to provide standard separation between IFR and VFR flights, nor between VFR flights, within Class G airspace.

1.18.3.2 ATC Responsibilities

Although separation standards are not applied in Class G airspace, ATC nevertheless has a responsibility to provide sufficient and accurate information to pilots to assist them to see and avoid each other.

Between the dates of the accident and of the publication of this report, there was a major change to the provision of air traffic services outside controlled airspace within the UK and, consequently, MATS Part 1 was revised substantially. Section 2 of MATS Part 1, dated 18 November 2010, states:

> *'Aerodrome Control is responsible for issuing information and instructions to aircraft under its control to achieve a safe, orderly and expeditious flow of air traffic and to assist pilots in preventing collisions between aircraft flying in, and in the vicinity of, the ATZ.'*

1.18.3.3 Aerodrome Traffic Monitor (ATM)

Section 2 of MATS Part 1 states that information derived from the ATM may be used to:

> *'a) Determine the landing order, spacing and distance from touchdown of arriving aircraft;*
>
> *b) Provide information to aircraft on the position of other aircraft in the circuit or carrying out an instrument approach.'*

1.18.3.4 Flight inspection of radio navigation aids and radar

All flights are allocated a category, which is designed for use as a method of tactical handling by ATC and which gives some flights priority over others. The categories, in descending order of priority are: Category A to E flights; normal flights; and Category Z flights. Category Z flights include training and other flights such as those being undertaken by both G-EYES and G-BOLZ.

Appendix C to MATS Part 1 gives guidance in respect of the priority to be given to flight inspection aircraft while calibrating radio navigation aids. It states that:

> *'Flight inspection aircraft may, where necessary, be allocated category E priority en route and should be fitted into the traffic pattern upon arrival at the aerodrome. Short delays to other aircraft may result, but this is preferable to the withdrawal of an aid because the flight inspection is overdue.'*

Although flight inspection aircraft normally need to operate in VMC, MATS Part 1 instructs ATC to treat such aircraft as IFR aircraft at all times. It also states that the ATC unit should obtain a detailed brief from the organisation conducting the inspection with regard to the flight profiles to be flown.

G-EYES was conducting training for flight inspection operations but was not actually carrying out such operations.

1.18.4 Coventry Airport Operational Notice – Low approach and go-around

In order to improve training value for a specific operator at Coventry Airport, an Operational Notice was issued such that, if one of this operator's instrument training aircraft received the standard clearance for a:

> *'low approach and go-around not below 400 ft above threshold elevation,'*

it could descend below 400 ft provided it was:

> *'at or above a height of 400 ft when passing the beginning of the Runway 23 starter strip.'*

Allowing the instrument training aircraft to continue its approach below 400 ft would give more time for any aircraft ahead to vacate the runway, which would otherwise result in the instrument training aircraft having to break off its approach at 400 ft. Consequently, there would be an increased likelihood that the aircraft on approach could continue to the Missed Approach Point of the procedure, which would maximise training value.

The notice prohibited the procedure being offered to any other training organisation and thus the procedure did not apply to the operator of G-EYES. However, the operator to which the procedure did apply also used the callsign prefix 'Atlantic'.

1.18.5 CAP 393 Air Navigation: The Order and the Regulations

Section 2 of CAP 393 details the Rules of the Air Regulations. Section 4, General Flight Rules, refers to the avoidance of aerial collisions and states:

> *'notwithstanding that a flight is being made with air traffic control clearance it shall remain the duty of the commander of an aircraft to take all possible measures to ensure that his aircraft does not collide with any other aircraft.'*

Referring to one aircraft overtaking another, CAP 393 states:

> *'an aircraft which is being overtaken in the air shall have the right-of-way and the overtaking aircraft….shall keep out of the way of the other aircraft by altering course to the right.'*

Referring to the order of landing, CAP 393 states:

> *'if an air traffic control unit has communicated to any aircraft an order of priority for landing, the aircraft shall approach to land in that order.'*

1.18.6 Unalerted see-and-avoid

The ATSB considered a number of factors in its research report, some of which are applicable to this accident. The report stated that:

> *'limitations, including those of the human visual system, the demands of cockpit tasks, and various physical and environmental conditions combine to make see-and-avoid an uncertain method of traffic separation.'*

It concluded that:

> *'the see-and-avoid principle in the absence of traffic alerts is subject to serious limitations.'*

The CAA recognised that the principle can be challenging in that it requires concentration and discipline to be effective. In the CAA's opinion, provided a thorough lookout is maintained at all times, see-and-avoid is effective, although it cannot guarantee that collisions will not occur.

The Transportation Safety Board of Canada issued a report[17] into a mid-air collision between two light aircraft operating VFR that addressed the issue of effective lookout. The report stated that:

> *'the United States FAA recommends that pilots spend 75 per cent of the time scanning a 180° by 30° field of view outside the cockpit. Estimates vary from 54 seconds to 9 minutes to perform the scan. In practice, pilots spend 33 per cent of the time scanning outside mainly within 10° of the direction of flight.'*

The report also stated that the effect of traffic alerting is to:

> *'increase the proportion of time spent scanning outside the cockpit. Attention is focussed on the known location of conflict, and the probability and range of detection increase.'*

On aircraft equipped with Traffic alert and Collision-Avoidance System (TCAS)[18], the pilot's attention is quickly directed towards the location of conflicting traffic. A report into unalerted visual acquisition[19] showed that one second of visual search with the aid of TCAS is as effective as eight seconds of unalerted search. Traffic alerting by ATC would be expected to generate similar improvements in search effectiveness.

1.18.7 Collision avoidance manoeuvres

CAA General Aviation Safety Sense Leaflet 13: *Collision Avoidance* states that:

> *'it takes a minimum of 10 seconds for a pilot to spot traffic, identify it, realise it is a collision risk, react and have the aircraft respond.'*

US Federal Aviation Authority (FAA) Advisory Circular 90-48-C estimates the equivalent time to be 12.5 seconds.

17 Aviation Investigation Report A06O0206
18 A system which provides the pilot with a visual display of other suitably-equipped aircraft in the vicinity. The level of threat is assessed electronically and conveyed to the pilot both visually and aurally.
19 Project Report ATC-152. Unalerted air-to-air acquisition. J.W. Andrews 26 November 1991

2 Analysis

2.1 General

Examination of the aircraft wreckages and technical records found no relevant pre-existing anomalies with either aircraft that could have caused or contributed to the collision and both aircraft appeared to have been maintained to the required standard. The electrical power distribution panel of G-EYES was probably disrupted in the collision; this may explain the loss of G-EYES' transponder signal after the collision.

In assessing why two serviceable aircraft collided in good weather conditions, the investigation considered organisational factors, the see-and-avoid principle and the judgement of the ADC in respect of the landing sequence.

2.2 Organisational factors

The operator of G-EYES did not appear to have followed the procedures outlined in its SMS that were to be used when undertaking a new flying activity because no risk analysis was produced, and there was no evidence that the planned calibration training had been discussed at the monthly safety meetings. However, discussions were held by the operator to consider possible problems and complications arising from flying an ILS approach at a higher than normal speed. Results of the discussions included the decisions to inform ATC about the higher speed of approach, and to operate the flights under IFR.

2.2.1 The decision to inform ATC

Although the crew of G-EYES explained their intentions on the radio prior to takeoff, it appeared that the information was insufficient for the air traffic controllers on duty to understand its full implications. There were no discussions between the operator and ATC managers about the calibration training. The consequent lack of knowledge within ATC probably contributed to the flight progress strip being incorrectly annotated 'IRT' because no code had been developed to denote 'ILS calibration work'. There was also no request for G-EYES to be given a higher priority than other traffic. Without prior knowledge of the calibration training, managers within ATC would have had no reason to carry out their own risk analysis or implement the procedures outlined in MATS Part 1 for use with actual flight inspection operations. Consequently, no special ATC procedures were developed in respect of G-EYES, and air traffic controllers on duty at the time of the accident had an incomplete understanding of the nature of the flight and the wider implications thereof.

2.2.2 The decision to operate under IFR

The decision to operate under IFR was taken with the intention of providing G-EYES with protection from visual circuit traffic while flying the ILS. Such protection might have been achieved by ATC providing G-EYES with standard separation from other aircraft, or by giving it priority over other aircraft. The intention to operate under IFR, however, was not communicated effectively to the air traffic controllers because they believed the aircraft was operating under VFR.

The applicable regulations state that within Class G airspace ATC is not required to provide standard separation between IFR and VFR flights, nor between VFR flights. As G-BOLZ was operating under VFR, the status of G-EYES – VFR or IFR – made no difference; standard separation was not required to be provided. Likewise, had G-EYES been operating under IFR, the ADC would not have had to give it priority over other traffic when integrating its arrival into the visual circuit. Contrary to the operator's belief, the ADC was permitted to instruct traffic on the ILS to position behind circuit traffic. The rationale behind the decision to operate under IFR was therefore flawed because it would not have resulted in greater protection being given to G-EYES.

Given the operator's apparent misunderstanding about the level of protection that would be provided, it is quite possible that the pilots of G-EYES thought that they were operating under IFR and therefore thought they would be given greater protection from other traffic than was actually the case.

2.3 See-and-avoid

The pilots of both aircraft were required to take all possible measures to avoid a collision by using the see-and-avoid principle augmented with traffic information from the ADC. Eyewitness evidence suggested that the pilots of G-BOLZ and G-EYES took no action to avoid the collision, suggesting that they either did not see each other, or did not see each other in time to take effective avoiding action. The investigation considered a number of significant factors that suggested why this was the case.

2.3.1 Visual acquisition

The section of this report beginning at paragraph 1.16 noted that the results of the discussion on visual acquisition should be considered indicative rather than definitive. The conclusions of that discussion are used in the following analysis and the caveat must be reiterated. It was not possible to determine accurately the range at which one aircraft could be seen from another. It was impossible to establish whether or when the pilots involved actually saw other relevant aircraft. Nevertheless, it was possible to use the conclusions to establish, to a reasonable degree of probability, the factors that influenced the outcome.

2.3.1.1 The pilot of G-BOLZ

The pilot of G-BOLZ was not given any information by the ADC about G-EYES' position or approach speed. The first time he would have known an aircraft was joining the circuit from the ILS was when the crew of G-EYES called on the Tower frequency one minute before the collision. The pilot probably had an unobstructed view of G-EYES after its angular size became large enough for it to be discerned, which was between about 46 and 19 seconds before the collision. However, he had been told his aircraft was number two in sequence and, as G-EYES was number three, it is possible that he thought G-EYES was not a threat, especially as he had no knowledge of its high speed.

Good airmanship dictates that a pilot should look along the final approach path in both directions before turning onto the final approach. However, 'looking' does not guarantee that a threat aircraft will be 'seen' and, once in the turn, it is natural to concentrate attention on where the aircraft is going. The pilot of G-BOLZ may also have been concentrating on maintaining adequate separation from the PA-28 ahead. It was impossible to determine whether or not he looked in the direction of G-EYES. There was no evidence that he manoeuvred to avoid the collision, suggesting that G-EYES was not seen at all or was seen too late for him to act.

2.3.1.2 The pilots of G-EYES

The handling pilot in the left seat of G-EYES would have been responsible for monitoring the normal flight instruments and the new monitor fitted to the instrument panel to guide the aircraft along the calibration profile. The view towards G-BOLZ from the left seat was probably unobstructed but this pilot's attention was likely to have been directed inside the cockpit for significant periods.

The commander in the right seat was training the handling pilot in calibration techniques and acting as safety pilot. She was expected to monitor the handling pilot's performance and maintain a lookout in accordance with the company's SOPs proposed for calibration flights. The training task would probably have reduced the time available for lookout by directing some of her attention inside the cockpit. However, even if she had been looking out during the minute preceding the collision, G-BOLZ would have been very difficult to acquire visually given its small size, position on the windscreen and the fact that it had no relative movement. It is also possible that it was hidden by the windscreen central pillar.

The ADC's transmission at 1035:30 hrs that the No 2 aircraft (G-BOLZ) was turning onto final when it was still on base leg may have prompted the crew of G-EYES to focus their attention ahead. If so, the pilots were less likely to look in the direction of G-BOLZ, reducing further the chance that they would see it.

In ideal conditions G-BOLZ might have been visible to the crew of G-EYES approximately 19 seconds before the collision and, in more realistic conditions, G-BOLZ should have been visible approximately 7 seconds before the collision. If it can take between 10 and 12.5 seconds for a pilot to identify a threat and react to it, and for the aircraft to respond to the control inputs, it is clear that the time required by the crew of G-EYES to take avoiding action would have been a significant proportion of the time available. It is also conceivable that the crew member primarily responsible for lookout was unable to see G-BOLZ in time to avoid the collision.

It was impossible to determine where the pilots of G-EYES were looking prior to the collision. Witness evidence was that the aircraft did not attempt any avoiding action, suggesting that G-BOLZ was not seen at all or was seen too late for the crew to act.

2.3.2 The role of ATC

The ADC was not passed a 10 nm range check by APC, as required by Coventry Airport's ATC procedures, but this omission did not appear to have contributed to the sequence of events that led to the accident.

Collision avoidance between aircraft within the visual circuit relies upon the see-and-avoid principle, which is fundamental to flight within Class G airspace, and controller judgement in respect of the allocation of landing order. It is every pilot's duty to take all possible measures to avoid collisions, regardless of any ATC clearance, and alerted see-and-avoid is considerably more effective than unalerted see-and-avoid in fulfilling this responsibility. In this case, no information was provided to the pilot of G-BOLZ alerting him to the presence of G-EYES. The ADC passed inaccurate information to G-EYES regarding the position of G-BOLZ. He advised the crew of G-EYES that they were number three to land with number two (G-BOLZ) turning final inside the NDB. At that time the PA-28 (number one) was turning final; G-BOLZ was still displaced approximately one nautical mile to the left of the centerline, approximately 27° left of G-EYES' nose.

Accurate traffic information alerts pilots to the presence of possible threats and increases the probability that conflicting traffic will be seen. The delivery of such information is essential and therefore the following Safety Recommendation is made with respect to MATS Part 1 dated 18 November 2010:

Safety Recommendation 2010-003

It is recommended that the Civil Aviation Authority ensures that the requirement in Part 1 of the Manual of Air Traffic Services for Aerodrome Control to issue '*information and instructions to aircraft under its control to achieve a safe, orderly and expeditious flow of air traffic and to assist pilots in preventing collisions*' is suitable, sufficient and complied with.

2.3.3 G-EYES' approach speed

Pilots may build their situational awareness based on what they regard as typical final approach speeds, which, for both commercial and general aviation aircraft, would be somewhat slower than 160 kt within 4 nm of touchdown. Air traffic controllers also need to be aware of higher approach speeds in order to be able to take account of the higher speed when formulating sequencing plans for circuit traffic. G-EYES was being flown at speeds of up to 160 kt down to 100 ft above the runway threshold. This differed sufficiently from what would normally be expected by pilots and ATC that it had the potential to adversely affect the situational awareness of pilots and the plans of the controllers, who were not fully aware of the purpose of G-EYES' flight and the planned flight profiles.

2.3.4 Rules of the Air Regulations

The crew of G-EYES was instructed to contact the ADC approximately 30 seconds later than planned and this, combined with the higher than normal approach speed, reduced the time available for the crew to build situational awareness before arriving in the visual circuit. The crew acknowledged the clearance to position number three in sequence, which placed upon the pilots an obligation to approach the runway in the order given. The pilots did not say whether they could see the two aircraft ahead but, given the lack of subsequent avoiding action, it is highly unlikely that they saw G-BOLZ. The PA-28 was 2.8 nm ahead at the time they acknowledged their sequence in traffic, with an angular size of 0.1°. This was half the minimum size required for it to be seen, according to the ATSB study, and so it is unlikely that the crew saw the PA-28 immediately.

Had there been any doubt in the pilots' minds about whether there was a risk of collision with the aircraft ahead, they should have broken off the approach by altering course to the right as theirs was the overtaking aircraft. However, the position at which they expected to see the number two in traffic was at least 2.25 nm ahead of them (the distance from G-EYES to the NDB). It was possible, therefore, that the crew thought they had sufficient time available to continue further along the approach while they looked for the aircraft ahead.

In ideal conditions, the PA-28 might have been visible to the crew of G-EYES at a range of 1.65 nm, which occurred at approximately 1036:19 hrs, 13 seconds before the collision. The crew had been directed to look in the direction of the PA-28, which increased the probability that it would be detected as soon as it became large enough to discern. It was possible, therefore, that approximately 13 seconds before the collision the crew of G-EYES saw the PA-28, believed it was the number two in traffic and satisfied themselves that they were approaching in the order given.

2.4 The landing sequence

The ADC thought that G-EYES was slower on the penultimate approach than on the accident approach and the data showed the difference to be approximately 6 kt. Perhaps of more significance was the fact that the approaches were accelerative: G-EYES gained 30 kt in the descent during the penultimate approach and 45 kt during the accident approach, both figures measured to the location of the accident. Normally, aircraft on approach have a constant speed or decelerate. It is probable that, on formulating his sequencing plan, the ADC projected it into the future using judgements about the future speed of G-EYES that were invalid because of his ignorance of the aircraft's speed profile. This problem was probably compounded by the delayed nature of the information displayed on the ATM used by the ADC. With a clearer understanding of the nature of G-EYES' flight, the ADC might have appreciated the potential consequences of the acceleration and developed a different plan. In the event, however, he judged that G-BOLZ could remain number two in sequence if it followed the PA-28 to final, a plan that was unlikely to have been successful.

After instructing G-EYES to continue the approach as number three, the ADC believed the sequencing issue was resolved and directed his attention to other aircraft. He did not realise there was a problem until he saw on the ATM that G-BOLZ had widened its base leg and was in conflict with G-EYES. By this stage, it was probably too late to prevent the collision.

3 Conclusions

3.1 Findings

1 The crew of G-EYES and the pilot of G-BOLZ were properly licensed and qualified to conduct their respective flights.

2 The air traffic controllers involved held relevant Certificates of Competence for their respective roles.

3 G-EYES and G-BOLZ were correctly maintained and were serviceable for their respective tasks.

4 Both aircraft appeared to have been operating normally before the collision.

5 All relevant ATC equipment was serviceable.

6 The collision occurred in Class G (uncontrolled) airspace and outside the Coventry Airport ATZ.

7 There was no evidence to suggest that the pilots took action to avoid the collision.

8 G-BOLZ was on a constant bearing relative to G-EYES for approximately three minutes prior to the collision.

9 It was estimated that at the point of collision G-BOLZ was crossing G-EYES' track at an angle of 43º and that G-EYES was overtaking G-BOLZ at a relative speed of approximately 106 kt.

10 The sightline to G-BOLZ from the front right seat of G-EYES probably intersected the canopy behind, or slightly to the left of, the windscreen central pillar.

11 The pilot of G-BOLZ was not informed about G-EYES approaching on the ILS.

12 At the time the crew of G-EYES was advised that G-BOLZ (number 2 in the landing sequence) was turning final inside the Coventry NDB, the PA-28 (number 1 in the landing sequence) was turning final inside the Coventry NDB. G-BOLZ had not yet completed its base leg.

13 The ATC Instrument Training booking sheet for G-EYES was annotated 'ILS calibration work' but this was incorrectly transferred to the flight progress strip as 'IRT', denoting Instrument Rating Training.

14 The ADC was not aware that G-EYES was undertaking calibration training because the flight progress strip was annotated with 'IRT'.

15 The operator of G-EYES did not appear to have followed the procedures outlined in its SMS that were to be used when undertaking a new flying activity because no risk analysis was produced, and there was no evidence that the planned calibration training had been discussed at the monthly safety meetings.

16 There was no discussion between the operator and ATC managers about the planned calibration training flights and how they would be integrated with other traffic.

3.2 Causal factor

The investigation identified the following causal factor:

> The two aircraft collided because their respective pilots either did not see the other aircraft, or did not see it in time to take effective avoiding action.

3.3 Contributory factors

The investigation identified the following contributory factors:

1. The likelihood that the crew of G-EYES would see G-BOLZ in time to carry out effective avoiding action was reduced by the small size of G-BOLZ, its position relative to G-EYES, and the high rate of closure between the aircraft.

2. Insufficient or inaccurate information was provided to the pilots, which did not assist them in fulfilling their duty to take all possible measures to avoid collisions with other aircraft.

3. The Aerodrome Controller's sequencing plan, which was based on an incomplete understanding of the nature of G-EYES' flight, was unlikely to have been successful. By the time the risk of a collision was identified, it was too late to devise an effective method of resolving the situation.

4. There were no effective measures in place to give G-EYES priority over traffic in the visual circuit.

4 Safety Recommendation

The following Safety Recommendation was made:

4.1 **Safety Recommendation 2010-003:** It is recommended that the Civil Aviation Authority ensures that the requirement in Part 1 of the Manual of Air Traffic Services for Aerodrome Control to issue '*information and instructions to aircraft under its control to achieve a safe, orderly and expeditious flow of air traffic and to assist pilots in preventing collisions*' is suitable, sufficient and complied with.

Appendix A

An explanation of airspace classification and flight rules as they pertain to this accident

1 Airspace classifications

The International Civil Aviation Organisation (ICAO) Airspace Classification System consists of seven classes of airspace, Classes A to G. The UK has adopted the ICAO System but only six classes have been implemented (no airspace is designated Class B in the UK). The UK has registered differences from the ICAO Standard for Class G airspace partly to allow greater flexibility to Visual Flight Rules (VFR) flights at and below 3,000 ft amsl.

An Aerodrome Traffic Zone (ATZ) around an airfield adopts the classification of the airspace in which it is situated.

2 Visual Flight Rules (VFR)

In order to operate under VFR, an aircraft must be flown in meteorological conditions better than the minima appropriate to the classification of the airspace. Such conditions are known as Visual Meteorological Conditions (VMC). In Class G airspace, at the altitudes flown by G-EYES and G-BOLZ, the relevant minima are:

Flight visibility of 5 km
Clear of cloud and with the surface in sight

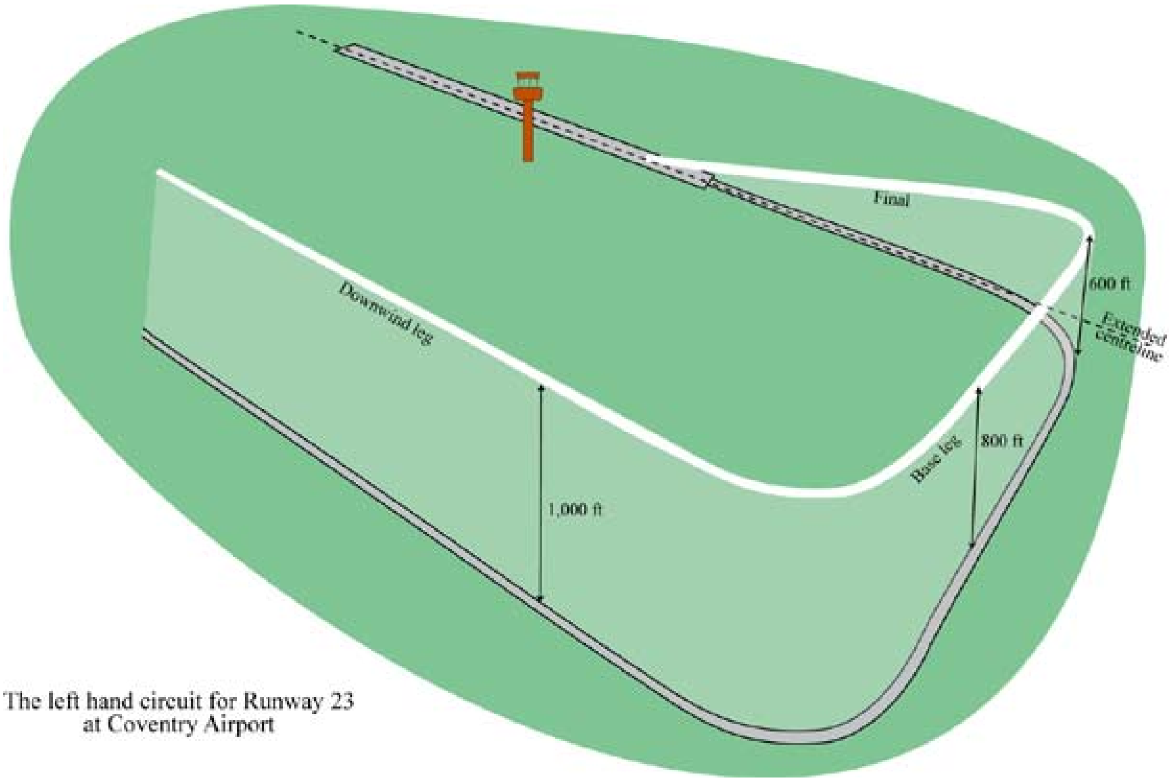
At the time of the accident, the visibility was more than 10 km and there was scattered cloud at 2,000 ft. These conditions allowed both aircraft to maintain VMC and, therefore, they were able to operate under VFR.

3 Instrument Flight Rules (IFR)

If a flight cannot be conducted in VMC, then it is in Instrument Meteorological Conditions (IMC) and must be operated under IFR. Additionally, a pilot may elect to fly under IFR regardless of whether or not the flight can be conducted in VMC. The Instrument Flight Rules require a pilot to observe the minimum height rule and additional rules according to the type of airspace. The minimum height rule, as it relates to this report, requires an aircraft to fly at a height of at least 1,000 ft above the highest obstacle within a distance of five nautical miles of the aircraft, except as necessary to take off or land. In Class G airspace, the additional rule is that pilots must comply with the quadrantal rule when in level flight above 3,000 ft amsl. In this accident, the aircraft were below 3,000 ft amsl so this did not apply.

Appendix B

An explanation of the visual circuit flown at Coventry Airport



The left hand circuit for Runway 23 at Coventry Airport

The visual circuit at Coventry Airport is flown at a height of 1,000 ft above the airfield. The airport is 267 ft above mean sea level (amsl), thus the circuit altitude is 1,300 ft amsl (1,267 ft rounded to the nearest 100 ft).

The downwind leg is flown parallel to the runway in a direction opposite to the landing direction and when an aircraft turns onto base leg, it begins its descent. As all turns within the standard circuit pattern are flown to the left, it is a left hand circuit and the base leg might be referred to as a 'left base'. The circuit has a left turn from base leg onto the final approach.

The standard circuit may be varied for operational reasons at the discretion of the Aerodrome Controller (ADC). An aircraft positioning for a right base leg would approach the extended centreline on a track which is a mirror image of the base leg shown. An aircraft on a right base would turn right onto its final approach.