AIRCRAFT ACCIDENT REPORT 5/2010

Air Accidents Investigation Branch

Department for Transport

Report on the accident between Grob G115E (Tutor), G-BYXR and Standard Cirrus Glider, G-CKHT at Drayton, Oxfordshire on 14 June 2009

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
Berkshire Copse Road
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August 2010

The Right Honourable Philip Hammond
Secretary of State for Transport

Dear Secretary of State

I have the honour to submit the report by Mr P Claiden, an Inspector of Air Accidents, on the circumstances of the accident between Grob G115E (Tutor), registration G-BYXR and Standard Cirrus Glider, registration G-CKHT at Drayton, Oxfordshire on 14 June 2009.

Yours sincerely

Keith Conradi
Chief Inspector of Air Accidents

Department for Transport
Air Accidents Investigation Branch
Farnborough House
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The Right Honourable Dr Liam Fox
Secretary of State for Defence

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Keith Conradi
Chief Inspector of Air Accidents

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GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AAIB	Air Accidents Investigation Branch
AEF	Air Experience Flight
agl	above ground level
AIAA	Area of Intense Aerial Activity
AIC	Aeronautical Information Circular
AIP	Aeronautical Information Publication
amsl	above mean sea level
ARC	Airworthiness Review Certificate
AS	Ankylosing Spondylitis
ATC	Air Traffic Control
ATSB	Australian Transport Safety Bureau
ATSOCAS	Air Traffic Services Outside Controlled Airspace
ATZ	Air Traffic Zone
BGA	British Gliding Association
BTR	Basic Training Requirement
CAA	Civil Aviation Authority
CAAFU	CAA Flying Unit
CAT	Commercial Air Transport
Cdr	Commander
CFS	Central Flying School
CG	Centre of Gravity
CS	Certification Standard
CTR	Control zone (controlled airspace)
cc	cubic centimetres
cm	centimetre(s)
°C,F,M,T	Celsius, Fahrenheit, magnetic, true
CtoI	Competent to Instruct
EASA	European Aviation Safety Agency
EFT(S)	Elementary Flight Training (School)
ELT	Emergency Locator Transmitter
FAR	Federal Aviation Regulation(s)
FAT	Flying Ability Test
FI(E)	Flying Instructor(Examiner)
FLARM	Flight Alarm
FMED4	Form Medical 4
Form 5000	RAF record of training
fpm	feet per minute
ft	feet
g	acceleration due to Earth's gravity
GA	General Aviation
GASCo	General Aviation Safety Council
Gp	Group
GPS	Global Positioning System
hrs	hours (clock time as in 1200 hrs)
hp	horse power
HQ	Headquarters
IAS	indicated airspeed
ISA	International Standard Atmosphere
JAA	Joint Aviation Authorities
kg	kilogram(s)
kg.m	Kilogram meters
KIAS	knots indicated airspeed
km	kilometre(s)
kt	knot(s)
LARS	Lower Airspace Radar Service
LBA	Luftfahrt-Bundesamt (German CAA)
lb	pound(s)
m	metre(s)
m/s	meters per second
mb	millibar(s)
MHz	Megahertz
MIG	Materials Integrity Group
min	minutes
mm	millimetre(s)
MO	Medical Officer
MoD	Ministry of Defence
MRU	Medical Rehabilitation Unit
N	Newtons
nm	nautical mile(s)
NOTAM	Notice to Airmen
OC	Officer Commanding
PDA	Personal Data Assistant
QRF	Quick Release Fitting
RAF	Royal Air Force
rpm	revolutions per minute
SCI	Spinal Cord Injury
TCAS	Traffic Collision Avoidance System
TGO(E)	Training Group Orders (Elementary)
TMA	Terminal Manoeuvring Area
TS	Traffic Service
UAS	University Air Squadron
UHF	ultra high frequency
UKAB	UK Airprox Board
USAF	United States Air Force
UTC	Co-ordinated Universal Time (GMT)
V	Volt(s)
V_{DO}	Design Diving speed
VHF	very high frequency
V_{NE}	Never Exceed airspeed
VMC	Visual Meteorological Conditions
VR(T)	Voluntary Reserve (Training)

Air Accidents Investigation Branch

Aircraft Accident Report No: 5/2010 (EW/C2009/06/04)

Registered Owner and Operator	1. VT Aerospace Ltd/ Royal Air Force 2. Private owner
Aircraft Type	1. Grob G115E (Tutor) 2. Standard Cirrus glider
Nationality	1. British 2. British
Registration	1. Tutor G-BYXR 2. Glider G-CKHT
Place of Incident	Drayton, Oxfordshire
Date and Time	14 June 2009 at 1317 hrs (All times in this report are UTC)

Synopsis

A Grob 115E Tutor aircraft, operated by the Royal Air Force (RAF), was undertaking a cadet air experience flight from RAF Benson. The visibility was good and the aircraft was conducting aerobatics, in uncontrolled airspace, when it collided with a glider. The left wing of the Tutor struck the fin of the glider causing the tail section to break away. The glider pilot parachuted to safety. The Tutor entered a spiral / spinning manoeuvre before diving steeply into the ground. The Tutor pilot and cadet were both fatally injured.

The Tutor pilot had a long term medical condition which restricted the movement of his head and affected his ability to conduct an effective look-out; this condition also made him more vulnerable to impact fractures of the spine. Following the collision it is probable that the Tutor remained controllable, suggesting that the pilot had become incapacitated.

The cadet's harness had been released and the canopy operating handle had been moved to the open position before the Tutor impacted the ground. The canopy jettison mechanism had not been operated.

The accident was notified to the Air Accidents Investigation Branch (AAIB) at 1350 hrs on 14 June 2009 and an AAIB field investigation was commenced immediately. The investigation was conducted by:

Mr P Claiden	Investigator-in-charge
Mr A Blackie	Operations
Mr B D McDermid	Engineering
Mr M Ford	Flight Data Recorders

The investigation identified the following causal and contributory factors:

Causal factor

1. Neither pilot saw each other in sufficient time to avoid the collision.

Contributory factors

1. The Tutor pilot's medical condition, Ankylosing Spondylitis, limited his ability to conduct an effective look-out.

2. The high density of traffic, in an area of uncontrolled airspace, increased the risk of a collision.

Thirteen Safety Recommendations have been made.

1 Factual information

1.1 History of the flight

1.1.1 Tutor (G-BYXR)

G-BYXR was one of six Grob 115E (Tutor) aircraft conducting air experience flights, for Air Cadets, from RAF Benson in Oxfordshire. The Tutor pilot involved in the accident reported for a pre-flight briefing at 0730 hrs on the morning of the accident but, as he was not required to fly until that afternoon he returned home. Following lunch, he returned to RAF Benson where, along with another pilot, he was re-briefed by the flight commander of the Air Experience Flight (AEF) and authorised for his planned sequence of five flights. These briefings covered the relevant local weather, NOTAMs and the planned flying programme for the afternoon.

The pilot commenced flying at 1200 hrs and completed two flights of 25 and 27 minutes respectively; both these flights were flown in the accident aircraft and were conducted without incident. The accident occurred on the pilot's third flight which departed at 1304 hrs.

The cadet was one of a group from his school flying that day. Having flown once on a previous day this was to be his second flight in a Tutor. On arriving at RAF Benson the cadets were briefed collectively on the day's activity and watched the 13 minute Tutor passenger safety video. When it was the cadet's turn to fly he was fitted with a flying suit, helmet, gloves and parachute by the safety equipment staff of the AEF. During the fitting, he was checked on his knowledge of the location of the parachute D-ring. When the cadet boarded the aircraft, he sat in the left seat; his harness was fastened to the quick release fitting by a member of the ground crew.

Following departure from RAF Benson, no further communications or sightings of the Tutor were made until shortly before it collided with a glider near the village of Drayton. However, the Tutor's flight was recorded by several ground radar installations.

Two witnesses observed the collision from the garden of their house in the village of Marcham, which is approximately 2 nm (12,000 ft) to the north-west of the accident site. Following the collision, both witnesses described the Tutor descending rapidly in a spin/spiralling manoeuvre and watched the aircraft until it disappeared behind an adjacent house. It was later established that the height would have been approximately 1,200 ft.

1.1.2 Glider (G-CKHT)

The pilot attended a mass briefing at Lasham at 0830 hrs which covered the weather, NOTAMs and a suggested 'task for the day'. The weather was forecast to be ideal for gliding. The pilot planned to fly the suggested task which was a triangular route: Lasham to Sherbourne in Dorset, a position to the east of Oxford, return to Lasham. He was aware that a large number of other pilots had expressed an interest in flying the same task.

One hundred and twenty eight gliders were launched from Lasham at a peak rate of 70-80 gliders per hour on the morning of the accident. G-CKHT was launched at 1015 hrs and by 1315 hrs it was approaching the village of Drayton, approximately 8 nm west of RAF Benson. The pilot was flying in close proximity to at least two other gliders, at approximately 4,000 ft amsl and a speed of 80 kt, when he became aware of the sound of a piston-engined aircraft. He saw a Tutor aircraft in planform, below and to the left of him, which then climbed vertically towards him. Realising that there was a high risk of a collision, he took evasive action by pitching up and rolling to the right. During this manoeuvre he lost sight of the Tutor, but could hear the engine noise getting louder. As the glider's speed decreased below 45 kt, a collision occurred. The glider pitched sharply nose down, causing the pilot to strike his head on the canopy.

With the glider pitching forward past the vertical, the pilot decided to abandon the aircraft and pulled the canopy operating knob with his left hand. As the canopy opened, he released his seat harness and fell forwards clear of the glider. He pulled the D-ring on his parachute, which opened beneath him, flipping him backwards as it fully deployed. He was immediately aware of the glider descending towards the ground like a sycamore seed with its tail separated from the fuselage. The glider pilot could also see the Tutor, which he described as diving almost vertically into the ground. He saw a thin blue smoke trail coming from the aircraft and heard the noise from the propeller steadily increasing during the dive. The glider pilot completed his parachute descent and landed safely.

1.2 Injuries to persons

1.2.1 Tutor (G-BYXR)

Injuries	Crew	Passengers	Others
Fatal	1	1	0
Serious	0	0	0
Minor/none	0	0	0

1.2.2 Glider (G-CKHT)

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Serious	0	0	0
Minor/none	1	0	0

1.3 Damage to aircraft

1.3.1 Tutor (G-BYXR)

The outermost 1.5 m of the leading edge of the left wing was damaged in the mid-air collision and the aircraft was destroyed when it struck the ground.

1.3.2 Glider (G-CKHT)

The tailplane, rudder and tail section broke away from the glider's fuselage during the mid-air collision.

1.4 Other damage

The Tutor crashed into a field of oil-seed rape damaging some of the crop.

1.5 Personnel information

1.5.1 Tutor pilot (G-BYXR)

Male	Age 62 years	
Licence:	Qualified Service Pilot	
Medical certificate:	RAF A3G2Z1 renewed 5 May 2009	
	JAA Class 2 renewed 5 May 2009	
Flying experience:	Total 9,560 hours (of which 478 were on type)	
	Last 90 days	30 hours
	Last 28 days	27 hours
	Last 24 hours	1 hour

The Tutor pilot joined the RAF in 1964 and had flown a variety of aircraft types, principally the Nimrod and the Bulldog. After retiring from the RAF in 2005 he rejoined in October of the same year as a Volunteer Reserve (Training) (VR(T)) pilot to fly with 6 AEF at RAF Benson. In June 2008, he attended an instructional technique course at 115(R) Squadron, RAF Cranwell. This course refreshed his previous service flying instructor experience and allowed him to conduct the basic flying instruction of University Air

Squadron (UAS) students. He was passed as competent to instruct (CtoI) and graded overall as 'high average'. His flying was also assessed during routine Flying Ability Tests (FAT). The most recent FAT recorded in the pilot's logbook was in May 2009. The most recent FAT recorded in his personnel file was undertaken in December 2008 by the officer commanding 6 AEF, when he was graded as above average in all areas.

Annex B of the RAF Training Group Orders (Elementary) (TGO(E)) 115 sets out the competency and currency requirements for AEF pilots. Section 4 states:

> *'CFS Standardization [sic] and CFS Visit. All AEF pilots are to be standardised by CFS Exam Wing within 2 years of appointment and 4 yearly thereafter, normally during CFS visits. If an AEF pilot misses a CFS standardisation he is to fly a FAT, with the UAS Cdr, Dep OC or AEF Cdr, before continuing with cadet flying and a CFS check is to be arranged without delay.'*

No record of this Central Flying School (CFS) check, which at the time of the accident was two years overdue, could be located for this pilot.

TGO(E)125.100.3 required the UAS Commander to conduct an annual check on each of the instructors on the UAS. There was a record in the Tutor pilot's logbook that this check was due on 10 June 2009. The check had initially been scheduled for February 2009, but had been cancelled and rescheduled for the week of the accident: this check was not required for AEF flying.

1.5.2 Glider pilot (G-CKHT)

Male	Age 27 years	
Licence:	BGA glider pilot's licence	
Medical certificate:	JAA Class 2 renewed March 2008	
Flying experience:	Total 1,000 hours (of which 3 hrs were on type)	
	Last 90 Days	60 hours
	Last 28 Days	55 hours
	Last 24 hours	2.5 hours

Although the pilot had only flown the Standard Cirrus glider for three hours prior to this accident, he had in excess of 300 hours on other types of gliders in the same class. He also held a Private Pilot's Licence and had accumulated approximately 300 hours flying powered aircraft.

1.6 Aircraft information

1.6.1 Tutor (G-BYXR)

1.6.1.1 General

The Grob G115E (Tutor) is a twin-seat (side-by-side) aircraft powered by a 180 hp Lycoming AE10-360-B1F piston engine driving a three-blade constant speed propeller. The aircraft is fully aerobatic and has a load factor limitation of +6 / -3g and a never exceed speed (V_{NE}) of 185 kt.

The aircraft has a fixed tricycle landing gear, electrically operated flaps and conventional manually operated flying controls, which use a system of push rods and bell cranks. The aileron and rudder control systems are interconnected via a spring unit, such that movement of one control will cause an appropriate small movement in the other control. The cockpit is equipped with dual flying controls with the two control columns connected to a lay shaft located under the seats. The majority of the airframe structure is manufactured from carbon fibre composite material. Both seats are equipped with a five-point harness, which is secured by a Quick Release Fitting (QRF).

The accident aircraft was equipped with conventional gauge instruments, a Mode A, C and S transponder, VHF and UHF radios and an Emergency Locator Transmitter (ELT). In addition, the aircraft was equipped with a differential GPS receiver (LX500TR), which incorporated a basic data logging function. The aircraft's position could be downloaded to a ground station from this unit via a data link, but this facility was not in use at the time of the accident.

The aircraft's Type Certificate was originally issued on 9 July 1999 by the LBA (German aviation authority) and is now held by EASA. Part of the certification requirements for this aircraft, CS 23.807, state that emergency exits must have a method of opening that is simple and obvious, and require no exceptional agility.

1.6.1.2 Windscreen and canopy

The Tutor is fitted with a single piece windscreen and a sliding canopy containing two large acrylic panels, Figure 1. The frame around the windscreen and the forward frame on the canopy are both approximately 9 cm wide. The two acrylic panels in the canopy are also attached to a frame located along the canopy centre line, which is approximately 16 cm wide. The canopy operating handle, which is coloured silver, is mounted on the forward section of this frame.

Figure 1

Windscreen and canopy

Visibility from the cockpit is generally very good and it is possible to see both tailplanes. Nevertheless, previous work undertaken by QinetiQ, in support of an investigation involving the mid-air collision of two Tutor aircraft, established that the canopy and windscreen frames can obscure part of the pilot's field of view. With a fixed head position for a pilot sitting in the right seat, the canopy and windscreen frame will obscure an area of sky, approximately, between 25° and 55° above the normal horizon and the lateral field-of-view between 25° and 47°. The QinetiQ report noted that it is possible for the pilot to look around this obscuration. The CAA test pilot reported that during his flight evaluation of the Tutor he was able to conduct a comprehensive look-out prior to each manoeuvre, without having to move his head extensively. AAIB inspectors, who have flown in the Tutor, also experienced no difficulty in looking around the windscreen and canopy frame.

The sliding canopy, which has a mass of 20.4 kg, is located on three guide blocks, which run on rails mounted on the fuselage spine aft of the cockpit and on each side of the fuselage, Figure 2. When the canopy is pushed closed it presses against a seal on the windscreen frame and four spigots on the bottom of the canopy engage in bushes mounted in the windscreen frame and on the canopy rail. To lock the canopy in the closed position, the operating handle is moved fully forward, causing a hook to latch onto a locking bracket mounted on the windscreen frame. The canopy can be moved along its rails by the use of handles mounted on the inside of the canopy.

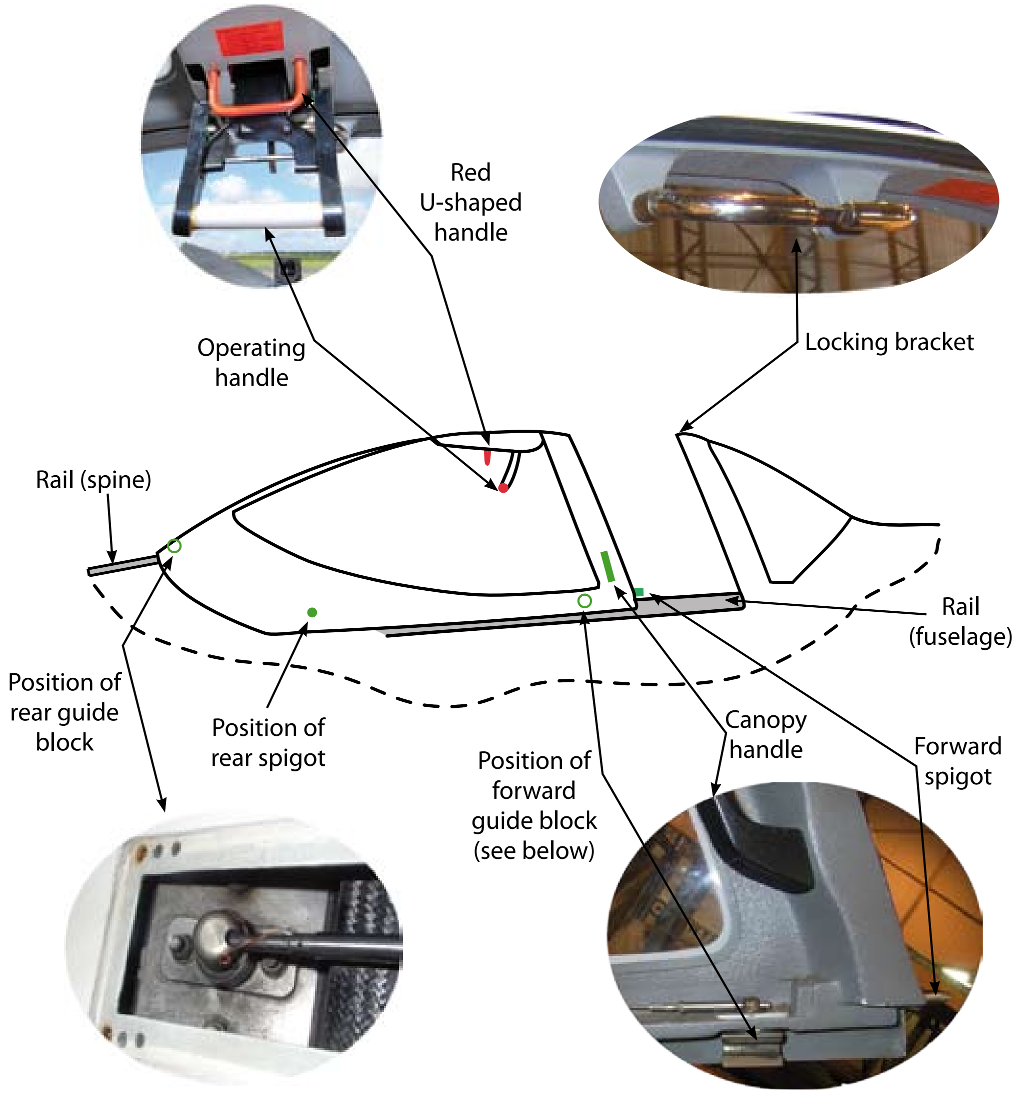


Figure 2

Canopy operating and jettison system

The canopy is opened in two stages. Firstly, the operating handle is moved rearwards until it reaches a stop just beyond the vertical position; this releases the hook from the locking bracket, Figure 3.

Once the hook has been released, the canopy can be moved rearwards along its rails using the canopy handles. The aircraft flight manual states that the canopy can be opened in flight at speeds up to 100 kt, but must be closed and locked when performing aerobatics.

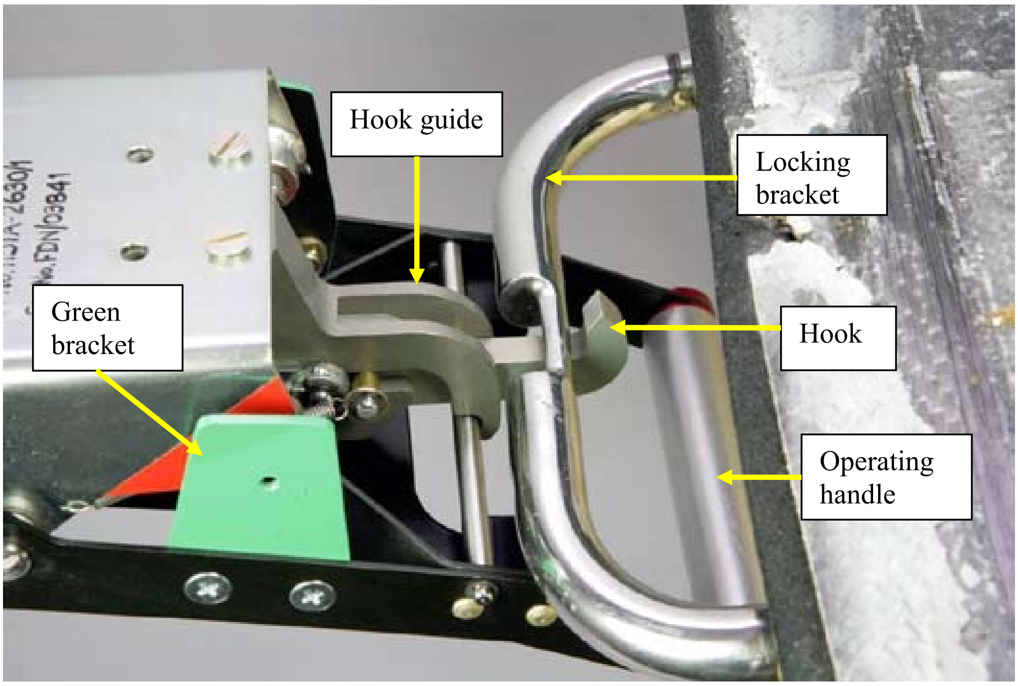


Figure 3

Salient features of the canopy operating mechanism, with the canopy in the closed and locked position

1.6.1.3 Canopy jettison

Jettison of the canopy on the Tutor requires three separate actions:

1. A 'U' shaped red handle (also called a 'jettison' handle and locking lever) must be pulled from the canopy operating mechanism. This allows the canopy operating handle to be moved rearwards by approximately 170°, which causes the hook to disengage from the locking bracket and withdraw from its guide.

2. As the canopy operating handle is moved rearwards beyond the vertical position, three Bowden cables operate and pull a 'jettison' pin out of each of the three canopy guide blocks, Figure 4. At this stage, the canopy is still attached to the aircraft by the four spigots.

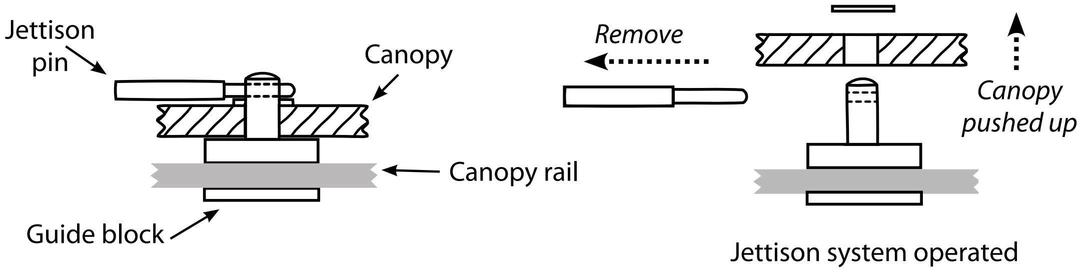


Figure 4

Operation of canopy jettison pins

3. The canopy must then be moved rearwards by approximately 4 cm, using the handles on the side of the canopy, in order to disengage the spigots from their locating bushes.

The Tutor operating guide contains the following:

> *'**WARNING:** To prevent a broken or dislocated arm resulting from the canopy sliding rapidly rearwards, the canopy must be opened using the pilot's 'inboard' arm, travelling across the body, and not the arm closest to the handle on the side of the canopy.'*

If the canopy does not detach from the aircraft, it must be pushed upwards away from the guide blocks.

1.6.1.4 Emergency locator transmitter (ELT)

The aircraft was equipped with an Artex ME406 ELT, which transmits a signal on the emergency frequencies 121.5 MHz and 406 MHz. The transmitter was mounted on the rear baggage bulkhead, located behind the cockpit, which was connected by a co-axial cable to an aerial mounted on top of the tail boom. The transmitter can be activated manually by a switch mounted on the right-hand side of the instrument panel, or automatically by an integral g-switch.

1.6.1.5 Weight and balance

The aircraft weight and balance at the time of the mid-air collision was calculated as 948 kg with a moment of 218.23 kg.m. This gave a centre of gravity of 0.23 m aft of the datum, which is within the limits published in the aircraft flight manual.

1.6.1.6 Maintenance

The aircraft was on a 150 hour maintenance cycle. The Airworthiness Review Certificate (ARC) was valid until 10 June 2010 and the last scheduled maintenance was a 50 hour check, undertaken by the operator's engineers on 8 June 2009, approximately 6 flying hours prior to the accident. The manufacturer had embodied a number of structural modifications approximately 35 flying hours prior to the accident. During this work the canopy was found to be stiff to operate which required the replacement of the canopy seals and rear guide. The operator advised the AAIB that following this rectification, the canopy operated satisfactory. The aircraft had no recent significant fault history.

1.6.2 Glider (G-CKHT)

1.6.2.1 General

The Standard Cirrus glider is a single seat glider constructed from glass fibre composite material and equipped with a single retractable main wheel and an all-moving tailplane mounted on top of the fin. It has a 15 m wing span, can carry water ballast and has a stall speed of 35 kt and a V_{NE} of 119 kt. The glider is fitted with an acrylic canopy, which is hinged along its right side. It is opened by pulling a red knob, mounted on the left side of the cockpit. To jettison the canopy, the pilot must pull both the red canopy opening knob and a red canopy jettison knob, mounted on the right side of the cockpit.

The glider was fitted with three 12v batteries and was equipped with two LX Navigation Colibri flight information recorders and a Garmin GPS II Plus portable GPS receiver. One of the LX Navigation Colibri data loggers (Colibri-F) incorporated FLARM[1]. In addition a PDA, incorporating a navigation programme for gliders, was mounted on a bracket in the cockpit.

The glider was white in colour with the civilian registration marked in red on the lower surfaces of the left wing and on both sides of the tail boom. The British Gliding Association competition number 424 was marked in red on the lower surface of the right wing and on each side of the fin and rudder.

1 FLARM is a flight alarm system that utilizes position and movement information obtained from an integrated GPS and an embedded altitude sensor. Once a second, the predicted flight path of the aircraft is transmitted over a low-powered, short-range radio as a digital message which can be received by other FLARM equipped aircraft. The system will display the position of other FLARM equipped aircraft and provide an audio warning if there is a risk of collision.

1.6.2.2 Weight and balance

The glider was not carrying water ballast and the pilot's weight was within the published limits for this aircraft.

1.6.2.3 Maintenance

At the time of the accident, the glider had flown for a total of approximately 2,407 hours over 1,218 flights. The last Airworthiness Review Certificate was issued on 4 February 2009 and the owner reported that there had been no recent fault history.

1.7 Meteorological information

The UK Met Office provided an aftercast of the area in which the collision occurred. There was no significant weather in the vicinity, the surface visibility was 25 to 30 km and the surface pressure was 1018 mb. The wind at 4,000 ft was estimated as 250° - 340° / 5 - 15 kt. The aftercast reported FEW/BKN cumulus or stratocumulus cloud with the base at approximately 5,000 ft amsl.

Pilots flying locally confirmed that this aftercast was broadly accurate with no significant weather likely to have an adverse effect on flying. From the surface position of the accident, the sun was at a bearing of 213° and an elevation of 58°.

1.8 Aids to navigation

Not applicable.

1.9 Communications

At the time of the accident neither aircraft was in receipt of an air traffic service. The glider pilot reported maintaining a listening watch on the common gliding frequency, 130.100 MHz.

The radio settings in the Tutor could not be determined; however, there was no evidence to suggest that the pilot had changed frequency from RAF Benson Tower. The RAF Benson ATC recordings were reviewed and no transmissions from the accident aircraft were recorded following its departure from the airfield. There were also no reports of any distress calls having been made on any other frequency.

At 1205 hrs and again at 1245 hrs, the Tower at RAF Benson broadcast an all stations warning concerning high density gliding activity near RAF Benson. Although the Tutor pilot was in his aircraft at the time of the transmissions, it was not possible to establish if he received this message; such warnings are not unusual at weekends and this information was not passed to the AEF supervising officer by either ATC or any of the AEF pilots.

1.10 Aerodrome information

Not applicable.

1.11 Flight Recorders

1.11.1 Accident protected flight data recorders

Neither aircraft was required to be, nor was, equipped with an accident protected data or voice recorder.

1.11.2 Radar and other sources of recorded data

Tutor (G-BYXR)

Recorded radar information was available from four radar sites, one at Clee Hill, one at Debden and two at London Heathrow. In relation to the accident site these are located approximately 70 nm to the north-west, 55 nm to the north-east and 26 nm to the south-east respectively. To differentiate the radars at London Heathrow, they are referred to by their respective wavelengths of 10 and 23 cm.

Both Mode A and Mode C (accurate to +/-129 feet) information was recorded from the Tutor's transponder during the flight; the Mode A 'squawk' was set to 7000, the general conspicuity code. Clee Hill, Debden and the London Heathrow radars record positional information once every eight, six and four seconds respectively. When combined, the radar records covered the time period from shortly after takeoff until a few seconds before impact with the ground.

The Tutor was also equipped with an LX Navigation Model 500TR combined navigation and GPS unit. However, the unit was severely damaged during the accident resulting in the loss of all stored data.

Glider (G-CKHT)

A complete record of the glider's accident flight was recovered from the LX Navigation Colibri-F flight information recorder. This provided aircraft GPS derived position and pressure altitude information once every three seconds. The unit was taken to the manufacturer where it demonstrated an average pressure altitude error of -37 ft when measured at increments between 0 ft and 22,966 ft. When set at a pressure altitude of 4,150 ft, the error was - 36 ft. The altitude recorded before departure from Lasham was accurate to within ten feet.

No other onboard equipment retained a record of the accident flight.

1.11.3 Data validity

About two minutes of data was also available from the London Heathrow 23 cm radar for the glider (G-CKHT). This data was from the latter stages of the flight, which assisted in validating the accuracy of the data retrieved from the Colibri-F flight information recorder.

The pilot of the glider reported that he had initiated a climbing right turn in an attempt to avoid the collision. This manoeuvre was apparent in the recorded data.

1.11.4 Flight information

Altitudes are referenced to ISA sea level pressure (1013.25 mb) unless otherwise stated. The calculation of aircraft separation and relative bearings has been based on data provided by the Colibri-F flight information recorder and radar information from the London Heathrow (10 cm) and Debden radars. It was established that the collision occurred between 1316:16 hrs and 1316:20 hrs. However, for clarity the timings in the following text are based on the collision occurring at 1316:18 hrs. The tracks of the Tutor and glider are detailed in Figures 5 to 11.

The glider approached the area from the south-west and, when approximately 3 nm from Drayton, completed a number of thermalling turns climbing to 4,500 ft. The glider then continued on a track of 030° towards Abingdon.

After departing RAF Benson, the Tutor passed Abingdon at 4,300 ft. It then made a series of turns with small changes in altitude (Point A), Figure 6 and 7, which brought it on to a westerly track, before accelerating to a ground speed

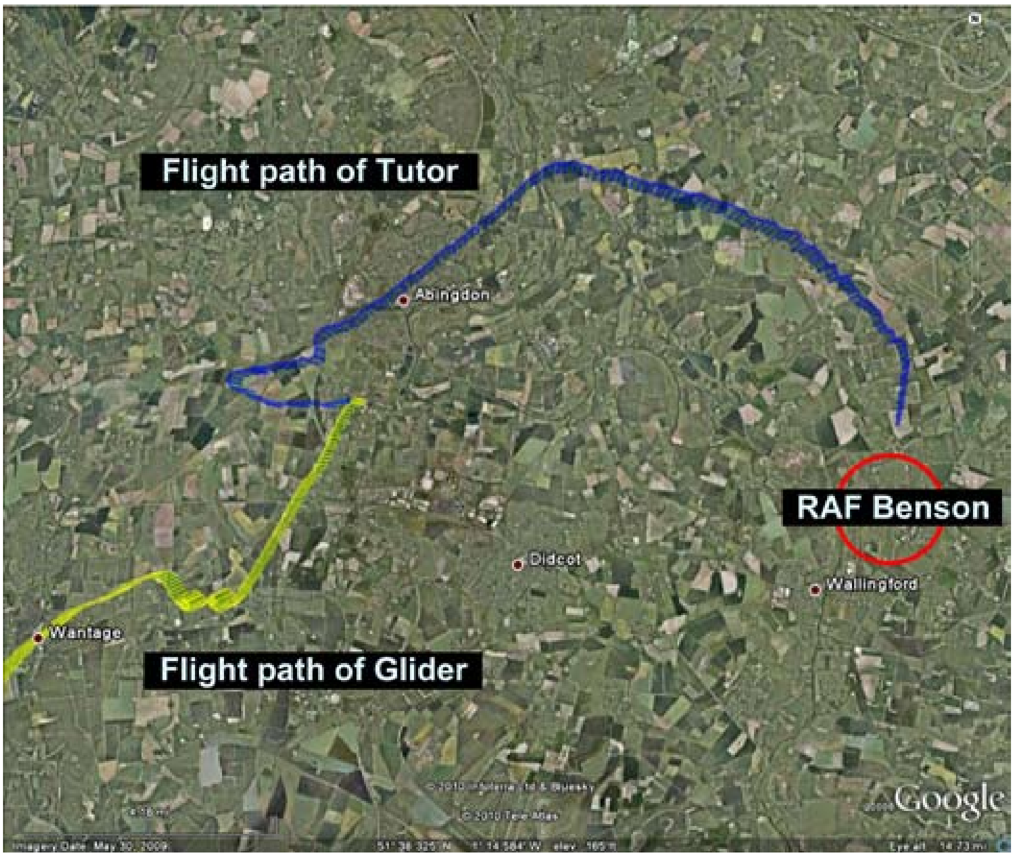


Figure 5

Flight tracks of Tutor (G-BYXR) and glider (G-CKHT)

of about 130 kt during a descent from 4,300 ft to 3,900 ft. During the next 12 seconds, the aircraft climbed rapidly to 4,700 ft, before again descending to 4,000 ft (Point B). The aircraft finished this sequence of manoeuvres at a similar position, and track, from where it had started.

The Tutor then made a left turn onto a track of about 110°, exiting the turn at about 4,300 ft. It was now positioned approximately 1.8 nm to the north-west of the glider, which was about 30° off to the right and at a similar altitude. This was 60 seconds before the collision.

The Tutor descended and accelerated to 3,900 ft, climbed rapidly to 4,700 ft and then descended to 3,800 ft (Point C). It exited this manoeuvre on a track of approximately 085°, at a similar position from which this manoeuvre had commenced. The aircraft were now 30 seconds from the collision and separated by 1 nm. From this position, the Tutor climbed to 4,200 ft and then started a gradual descent.

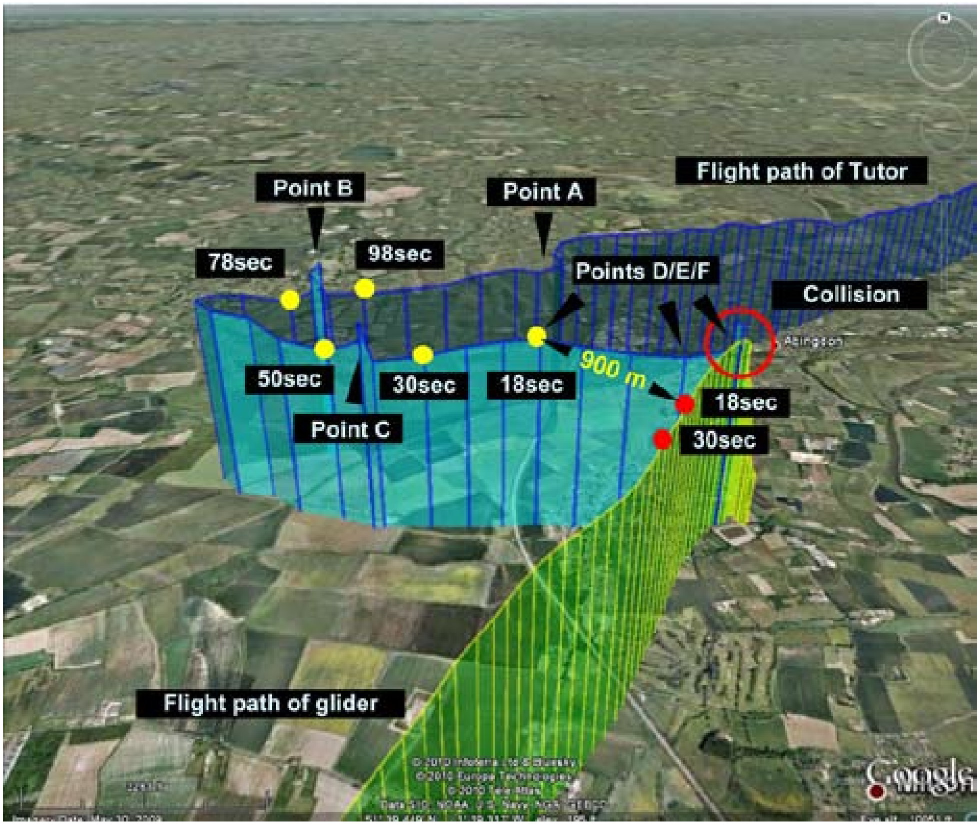


Figure 6

Relative flight paths of Tutor (G-BYXR) and glider (G-CKHT) as viewed from the south

At 18 seconds before the collision, separation had reduced to 900 m with the glider positioned about 30° to the right and 100 ft below the Tutor (Point D).

At 10 seconds before the collision, the Tutor had descended to approximately 100 ft below the glider and the separation between the two aircraft had reduced to about 450 m.

At 6 seconds before the collision, separation had reduced to about 230 m, with the Tutor now at 3,800 ft and the glider at 4,107 ft, positioned about 30° to the right of the Tutor's track (Point E).

If the maximum altitude accuracies[2] of the Tutor's transponder, and the glider's flight information recorder, are applied and the Tutor was flying straight and level, then the relative position of the glider would have been between 16° and 32° above the Tutor. However, as the separation reduced, the glider would have moved higher in the Tutor pilot's field-of-view.

2 The reported accuracy of G-BYXR's transponder system was +/-129 feet and G-CKHT's flight information recorders average error was -37 ft.

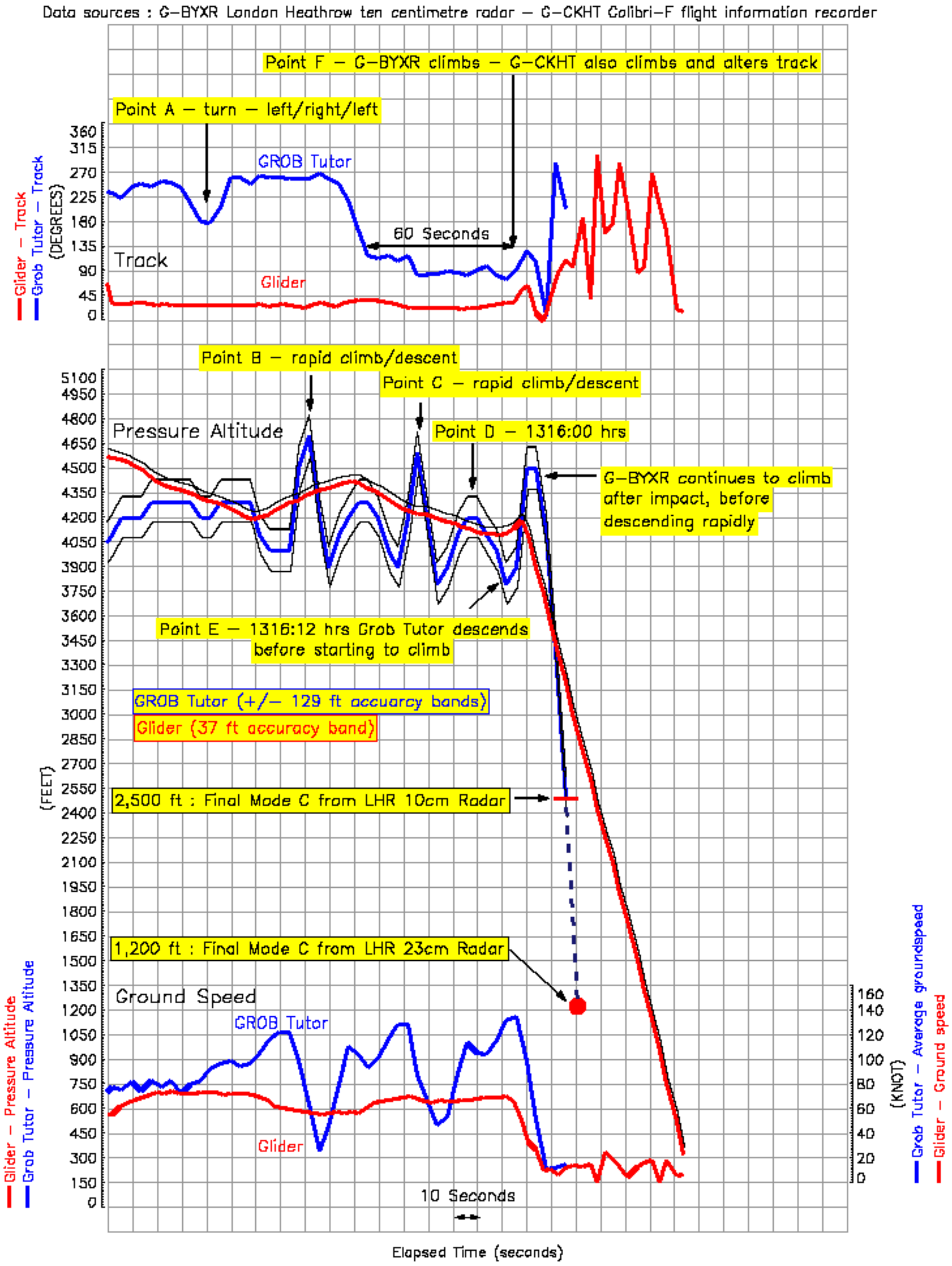


Figure 7

Relative attitudes of Tutor (G-BYXR) and glider (G-CKHT)

At 2 seconds before the collision, the Tutor's ground speed increased to 130 kt and at the same time the glider started to climb and turn to the right (Point F). Over the next 4 seconds, the Tutor climbed rapidly from 3,900 ft to 4,500 ft at an average rate of 9,000 fpm.

The collision occurred during this final manoeuvre between 1316:16 hrs and 1316:20 hrs at an altitude of approximately 4,150 ft.

Following the collision there was a second altitude return from the Tutor of 4,500 ft and during the next 12 seconds the aircraft descended from 4,100 ft to 1,200 ft at an average descent rate of 14,500 fpm (143 kt).

The transponder in the Tutor provided information every four seconds at pressure altitudes of 4,500 ft, 4,100 ft, 3,400 ft, 2,500 ft and 1,200 ft. Applying a transponder accuracy of +/- 129 ft, the average minimum, average maximum and mean vertical speeds during each of these time periods were:

- 4,500 ft to 4,100 ft, between 20 kt and 97 kt – mean of 59 kt (29 m/s)
- 4,100 ft to 3,400 ft, between 65 kt and 143 kt – mean of 104 kt (53 m/s)
- 3,400 ft to 2,500 ft, between 94 kt and 171 kt – mean of 133 kt (68 m/s)
- 2,500 ft to 1,200 ft, between 154 kt and 230 kt – mean of 193 kt (99 m/s)

Following the collision, the glider descended, initially altering track to the left before entering a descending right turn.

1.11.5 Proximity to other aircraft

The investigation identified a number of other aircraft which were in close proximity to the accident aircraft around the time of the collision, Figures 8 to 10.

There were four other gliders (Glider 1 to 4) and one powered aircraft operating within 3.5 nm of the accident site about 80 seconds before the collision. The nearest aircraft was a glider, which is referred to as Glider 1, positioned about 0.7 nm from the Tutor and 1 nm mile from the glider (G-CKHT).

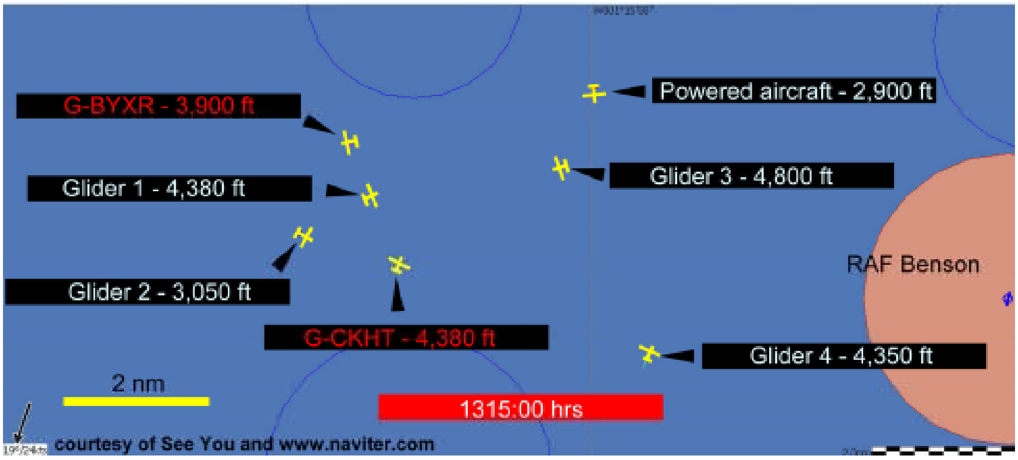


Figure 8

Proximity of other aircraft 78 seconds before the collision

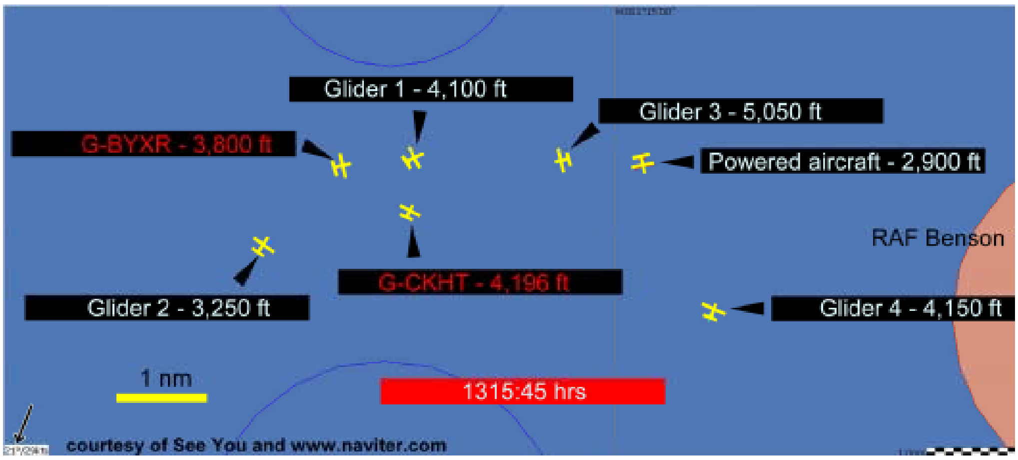


Figure 9

Proximity of other aircraft 33 seconds before the collision

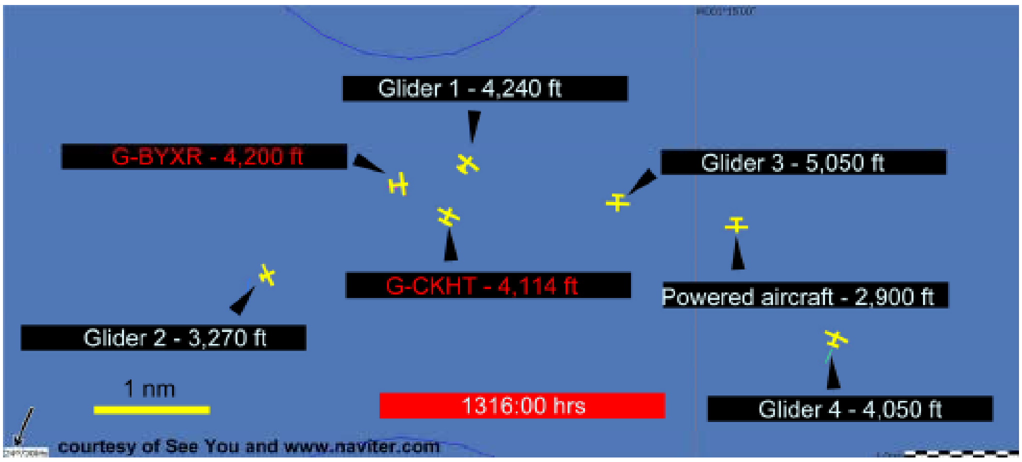


Figure 10

Proximity of other aircraft 18 seconds before the collision

30 seconds before the collision, when the Tutor exited its manoeuvre, Glider 1 would have been approximately 300 ft above and 0.8 nm directly ahead of the Tutor. The glider (G-CKHT) was just over 0.5 nm to the south of Glider 1, and about 1 nm to the south-east of the Tutor.

15 seconds before the collision, the separation between the two accident aircraft had reduced to about 0.5 nm with the glider remaining on a relative bearing about 30° to the right of the Tutor. Glider 1 remained on its previous track and had passed from right to left ahead of the Tutor; it was now on a relative bearing of approximately 20° to the left of the Tutor, at about the same altitude with a separation of 0.6 nm.

Glider 1 was about 1 nm to the north-east when the collision occurred. Another glider (Glider 3) was nearly 2 nm away, about 800 ft above the Tutor and within +/- 30° of its track.

The relative flight of Glider 1 and the accident aircraft prior to the collision is shown at Figure 11.

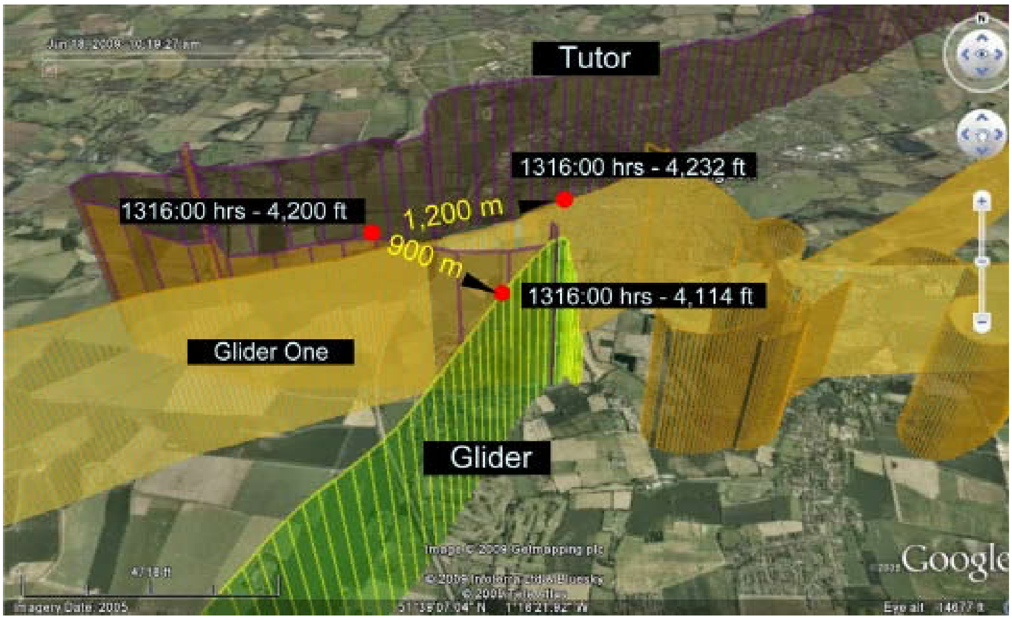


Figure 11

Relative flight path of Glider 1 in relation to accident aircraft

1.11.6 Traffic density in the vicinity of RAF Benson

To establish traffic density at the time of the accident, data was obtained from radar sources, the British Gliding Association (BGA) and its members.

For the purpose of confirming that a glider task[3] has been completed, many pilots equip their gliders with GPS-based devices that record both the glider's track and altitude against time. These flight records may then be uploaded to the BGA ladder website as proof of a task having been completed. On the day of the accident, 243 flights were registered on the website, with 165 providing flight records from a recording device. Following an appeal by the BGA, a further 36 flight records were provided by glider pilots who had been flying in the area that day. Of 201 flights, about half transited the gap between the RAF Brize Norton CTR and the RAF Benson ATZ. The flights took place between 0920 hrs and 1900 hrs, with the highest volume of traffic occurring between 1200 hrs and 1600 hrs. Flights originated from various aerodromes and glider launch sites across the UK. In addition to flight records from the BGA, data was also obtained from the London Heathrow radars. Between 1200 hrs and 1330 hrs, just fewer than four hundred radar tracks were recorded for flights operating at or below 6,500 ft across the south of England.

From the combination of nearly 600 flight records, it was established that between 1200 hrs and 1330 hrs, 118 aircraft had operated within 10 nm of RAF Benson, with the majority of these aircraft routing through the gap between the RAF Brize Norton CTR and RAF Benson ATZ, Figure 12 and 13. Of the 118 aircraft, 85 were identified as gliders and 33 as powered aircraft, both fixed and rotary wing. During the same period, 6 AEF also flew 19 flights from RAF Benson, of which 12 are included in the radar data. This does not include the accident flight, Figure 14. The majority of the 118 aircraft transited the area where the accident occurred. Between 1200 hrs and 1330 hrs, there were, at any one time, 15 to 25 aircraft operating within a 10 nm radius of RAF Benson; the accident location was about 8 nm to the west of RAF Benson.

The highest volume of flights registered on the BGA website for June 2009, was on the day of the accident with 201 flights. The previous day, which had 104 flights, was the next highest during the month.

3 A task is a flight that consists of a number of predefined turning points, usually ending at the point of departure.

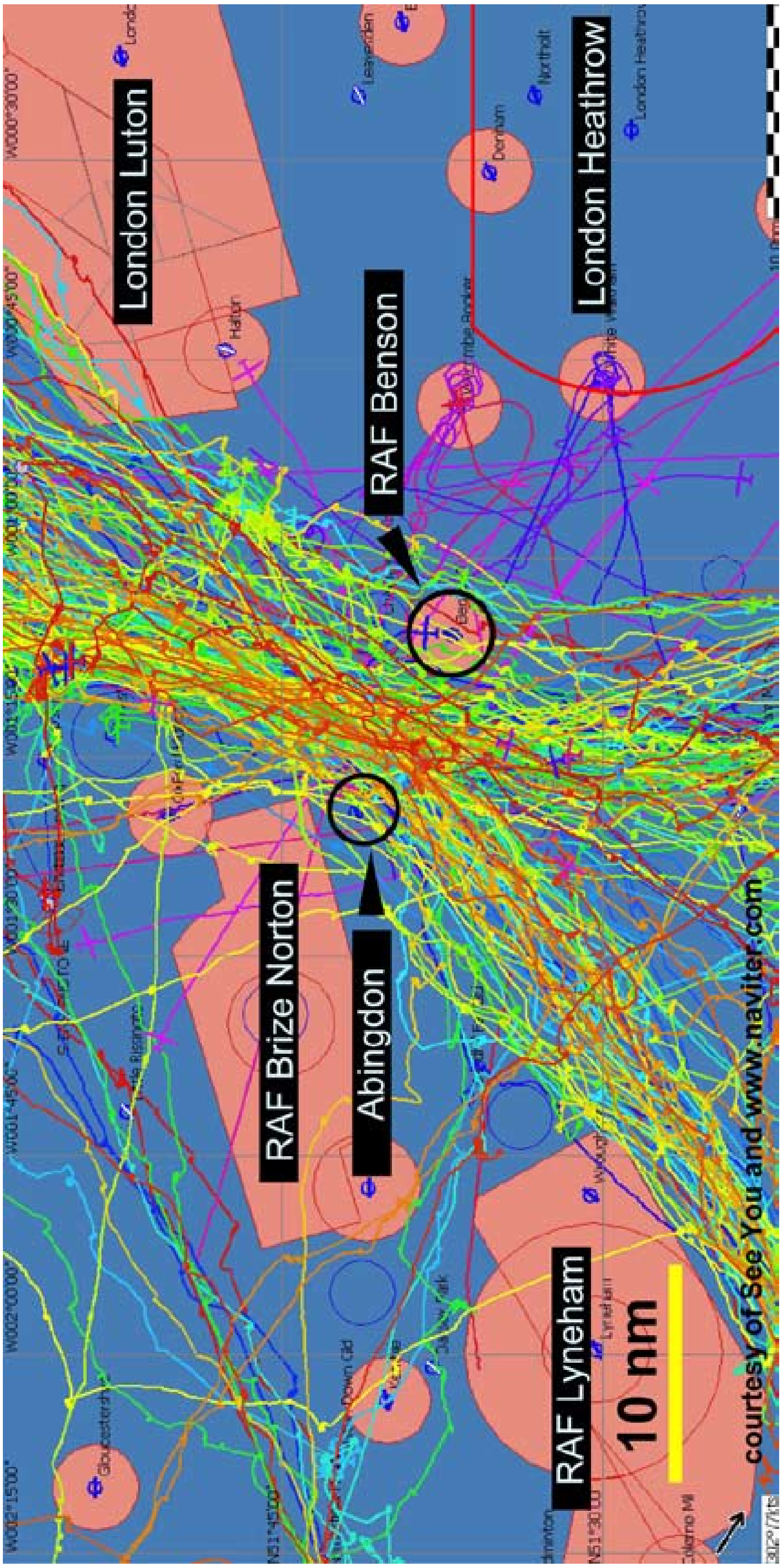


Figure 12

Flight tracks of 118 aircraft between 1200 hrs to 1330 hrs (10 nm)

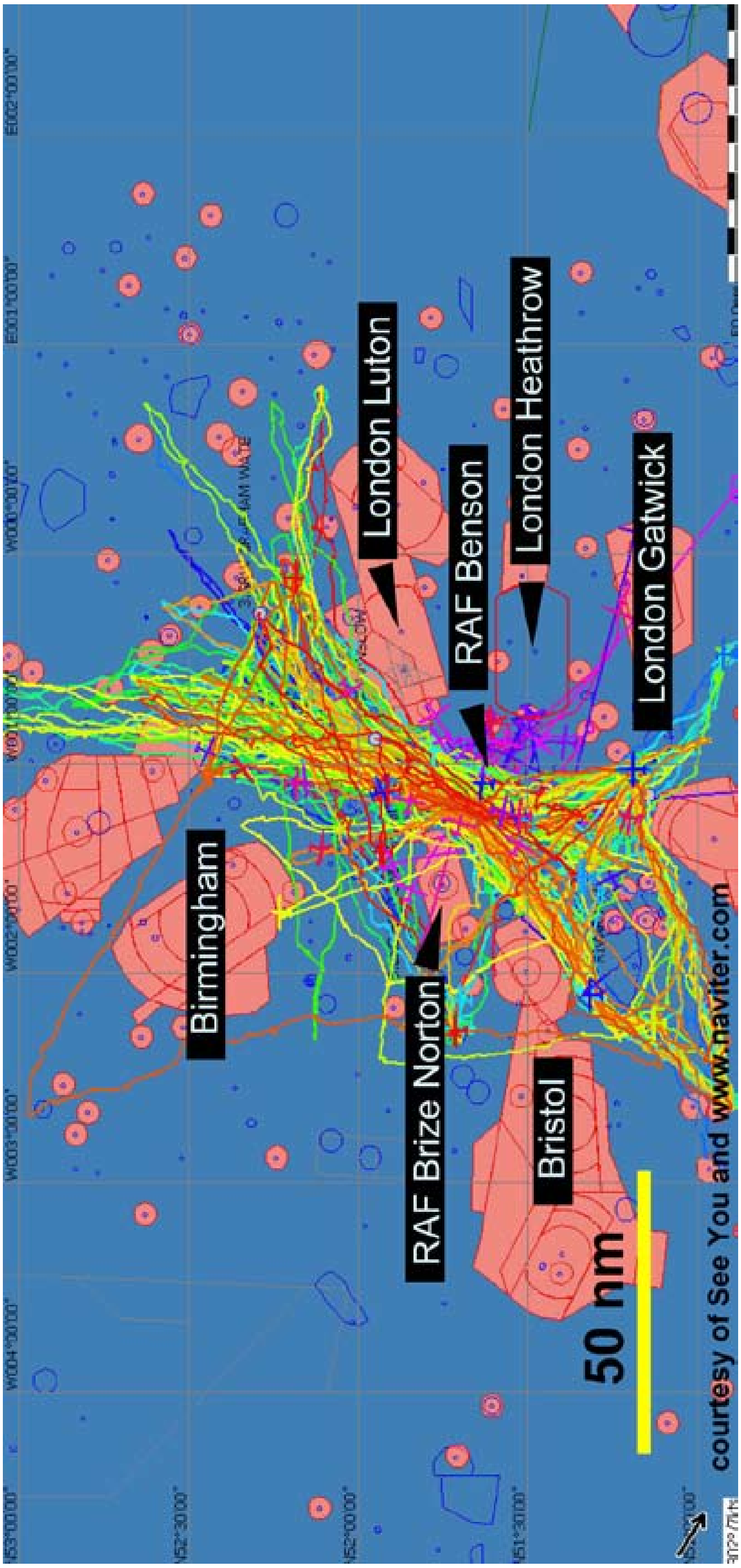


Figure 13

Flight tracks of 118 aircraft between 1200 hrs to 1330 hrs (50 nm)

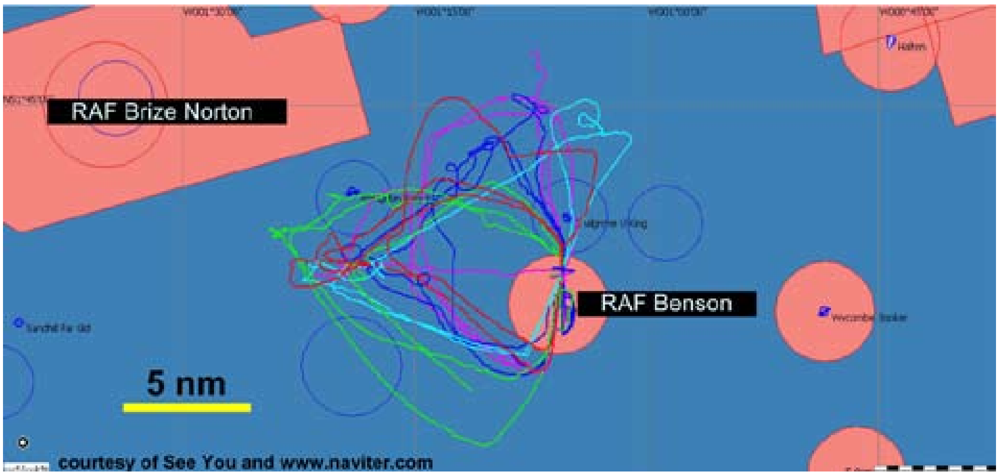


Figure 14

Tutor flights between 1200 hrs and 1330 hrs

1.12 Wreckage, impact information and aircraft examination

1.12.1 Accident site

The Tutor and glider were found in adjacent fields approximately 200 m to the east of Drayton village.

The Tutor impacted the ground at an angle of 70° to 80° below the horizon on a heading of 030°; the wreckage was contained within an area approximately 14 m^2. The ground mark from the right wing was slightly deeper and more distinct than the mark made by the left wing. From the distribution of the wreckage, and the ground marks, it was established that the wings were level and there was no evidence of any lateral motion of the aircraft as it struck the ground.

The glider crashed in a field of stubble approximately 200 m south-west of the Tutor wreckage. The tail section, less the tailplane and rudder, was found approximately 75 m to the south-west. From the ground marks it was established that the glider impacted the ground on the right wing tip, causing this wing to break at a position approximately 2.75 m from the wing tip. Part of the canopy frame and acrylic material from the canopy were found with items from the cockpit close to the front of the glider.

1.12.2 Wreckage trail

The combined wreckage trail extended for approximately 1 km, aligned along a track of 130°. It encompassed a small residential area, agricultural land containing a mixture of open fields and mature crops, and a large local authority maintenance yard, Figure 15. The glider pilot landed approximately 980 m from his aircraft and the majority of items found in the wreckage trail came from the glider. In addition to the significant items of wreckage detailed in Table 1, pieces of acrylic from the glider canopy and small pieces of glass fibre material were found throughout the wreckage trail.

Item from glider	Distance from glider
Tailplane nose weight	120 m
Fin	74 m
Rudder	212 m
Left section of tailplane	520 m
Right section of tailplane	790 m

Table 1

Distribution of wreckage

The only part of the Tutor found in the glider wreckage trail was a 0.65 m section of the leading edge of the left wing. This was found approximately 800 m from the aircraft wreckage and 16 m from a small piece of glass fibre structure originating from the glider. This piece of glass fibre was later identified as being from the area where the right side of the tailplane attached to the fin of the glider.

1.12.3 On-site examination of Tutor (G-BYXR)

Airframe and engine

The Tutor impacted the ground at high speed and at a very steep angle. The main wing spars remained intact and the skins forward of the front spar had been severely damaged with the carbon composite material along the leading edge broken into a large number of small pieces. In comparison, the damage to the wing skins between the front spar and trailing edge was less severe and although the skins had disbonded from the spars, they remained in relatively large sections. Both wing fuel tanks had disintegrated and, whilst there were no physical signs of a fire, a strong smell of burnt fuel and structure was present several hours after the accident. This suggested that a flash fire had

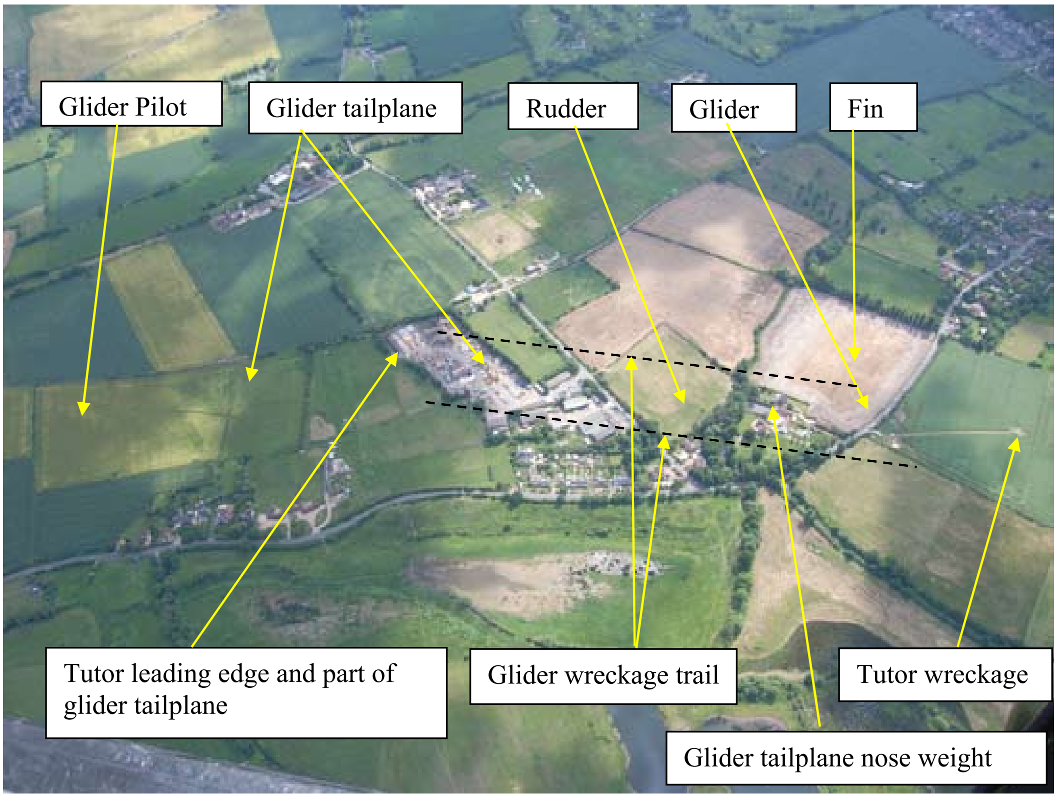


Figure 15

Distribution of wreckage

occurred. The ailerons and flaps were relatively undamaged and the wing access panel at the left wing tip had been driven vertically into the ground.

The front of the engine was buried approximately 0.7 m into the ground at an angle of 70° to 80° and all the engine components were badly damaged. All three propeller blades had shattered.

The carbon structure in the tail cone had shattered, allowing the tail section to collapse onto the forward part of the aircraft, before toppling backwards onto the ground. The upper and lower skins on the right tailplane had disbonded, and a large piece of the wing structure was embedded in its leading edge. There was similar damage to the leading edge of the left tailplane. The skin along the outboard trailing edge of the right tailplane had disbonded and the outer elevator mounting bracket had rotated by 90°, allowing the elevator locating pin to come out of its bearing. The counterweight on the left elevator had pulled away from the upper skin. Damage and black carbon marks along the leading edge of the fin were consistent with it being struck by the carbon composite structure during the ground impact.

Flying controls

The flying controls were inspected before the aircraft was removed from the site. Whilst they were extensively damaged, all the damage was consistent with it having occurred when the aircraft impacted the ground. No evidence was found of any control restriction being present prior to impact.

Canopy

The cockpit area was badly disrupted and the canopy and windscreen structure had detached from the aircraft. There was no evidence of any part of the glider having penetrated the cockpit. The canopy acrylic material had shattered and its support frame had broken into three parts. The external and internal canopy operating handles were found in the open position; the operating mechanism had been extensively damaged. The red 'jettison' handle was found under wreckage in the left foot-well.

The centre part of the canopy frame had failed just forward of the operating mechanism. The composite material aft of the mechanism had been badly damaged as a result of the mechanism moving upwards with sufficient force to shear all three canopy jettison cables. The left and right canopy jettison pins were still located in their guide blocks, with the 'tell-tale' wires intact. The jettison pin had withdrawn from the central canopy guide block.

Cadet's harness

The left seat harness was found undone and the QRF, attached to the crotch strap, was found trapped under the seat. Both the lap straps were still attached by the supporting bracket (which had not deformed) to the aircraft structure. The shoulder straps were attached to the seat back, which had broken away from the aircraft. The QRF was found to be in the locked position and the screws securing the protective backing plate had sheared. The rear of the QRF was distorted in a direction consistent with it being trapped between the control column and the front of the seat. All the lugs on the harness, which fit into the QRF, were undamaged.

All the evidence was consistent with the left seat harness having been released prior to ground impact.

Pilot's seat and harness

The right seat back had broken away from the aircraft and, whilst the shoulder straps were intact, the webbing on the lap and the crotch straps had failed as a result of having been subjected to large tensile forces. Both lap strap supporting brackets had undergone longitudinal deformation in a direction consistent with the lap straps having been fastened at the time of impact. All the straps were found connected to the QRF, which was in the locked position.

All the evidence was consistent with the right seat harness having been fastened during the ground impact.

1.12.4 On-site examination of glider (G-CKHT)

It was assessed that the damage to the glider's cockpit area and right wing occurred when the glider impacted the ground. There was no evidence of any pre-ground impact damage on any part of the glider, other than the tail section, which had broken away from the fuselage in-flight.

The damage to the tail section indicated that it had failed as a result of a force from the right. The rudder had detached from the fin and damage to the hinge indicated that this had also been subject to a force from the right. The tailplane had broken into three sections: the nose section incorporating the balance weight, and the left and right sections of the tailplane. The damage to these sections, and the attachment point on the fin, was consistent with an impact to the inboard lower skin on the right side of the tailplane.

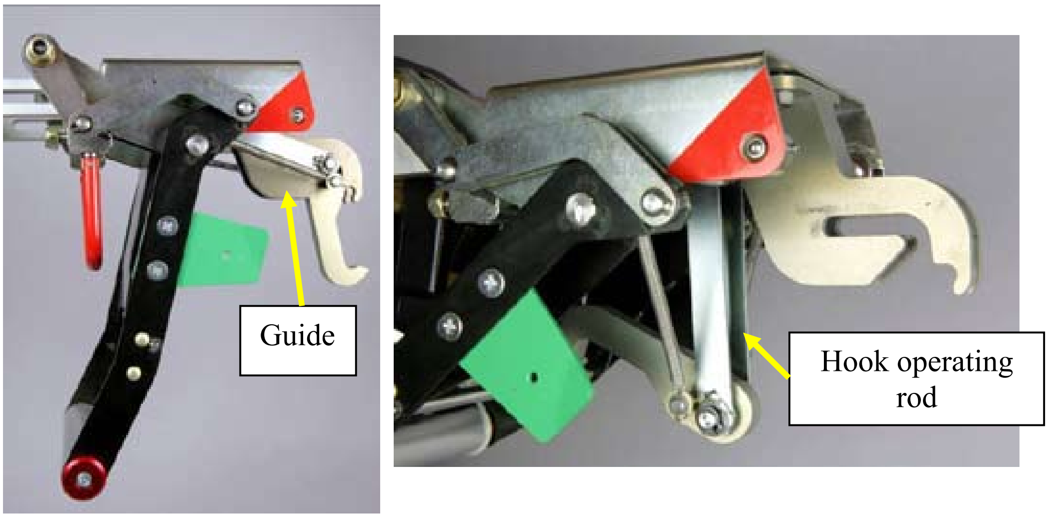
It was established that the glider's canopy jettison mechanism had not been operated and part of the canopy frame remained attached to the cockpit structure. Relatively little of the canopy transparency was found at the accident site, with the majority of it being recovered from the debris trail. One large piece of acrylic material was found in the maintenance yard.

1.12.5 Detailed examination of Tutor (G-BYXR)

1.12.5.1 Canopy operating mechanism

During the investigation, the AAIB and Fleet FS (Air) Materials Integrity Group (MIG) examined the canopy operating mechanism on the accident aircraft (G-BYXR) and compared the damage with that sustained to the mechanisms on two other Tutor aircraft, G-BYVN and G-BYUT, which were involved in a mid-air collision on 11 February 2009.

The salient features of the canopy operating mechanism are highlighted in Figure 3. Figure 16 shows the position of the hook and operating handle in the canopy 'open' and 'jettison' positions. In the open position, the hook is still retained in the hook guide, whilst in the jettison position, the operating handle moves further rearwards and the hook withdraws from the guide.



Open position Jettison position

Figure 16

Canopy operating mechanism in the open and jettison position

Canopy locking bracket

The canopy locking bracket, Figure 17, was slightly bowed upwards and a dent was apparent approximately 4.5 cm from the centre of the catch. No evidence was seen of any transfer of green paint or any damage to the green brackets, which might have occurred had the operating handle been in the closed position during the impact. The damage to the locking bracket is also significantly different from the damage seen on G-BYVN, where the canopy was assessed as being closed during the ground impact. This further suggests that the canopy locking mechanism was in the open position when G-BYXR struck the ground.

Hook guide

The left lug on the hook guide had failed in overload, consistent with a force being applied from the right, and the right lug was bent to the left, Figure 18. This damage could only have occurred if the hook was not located between the lugs at the time they were deformed. Normally, for the hook to withdraw

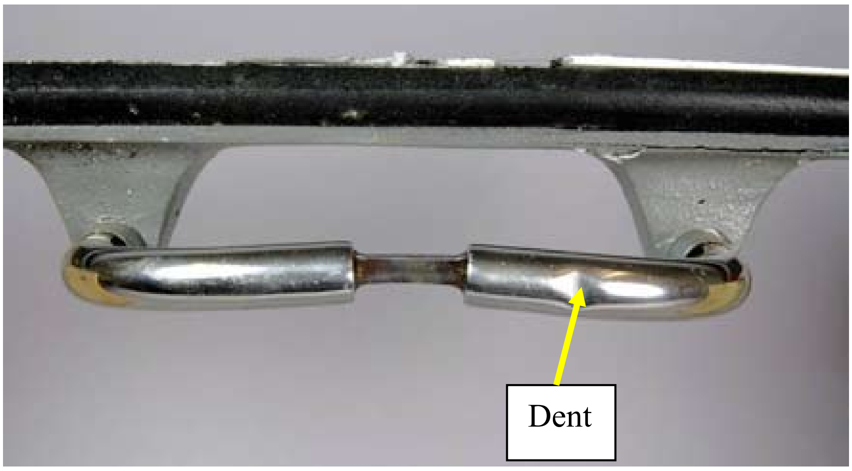


Figure 17

Canopy locking bracket on G-BYXR

from the guide the red 'jettison' handle has to be removed and the canopy operating handle moved rearwards by more than 90°. However, the lower shaft, at the base of the operating handle, Figure 19, which is connected to the hook operating rods, had bent and one of the circlips had failed during the impact. This damage would have allowed the hook, in the open position, to disengage from the hook guide without the 'jettison' handle having been removed from the housing.

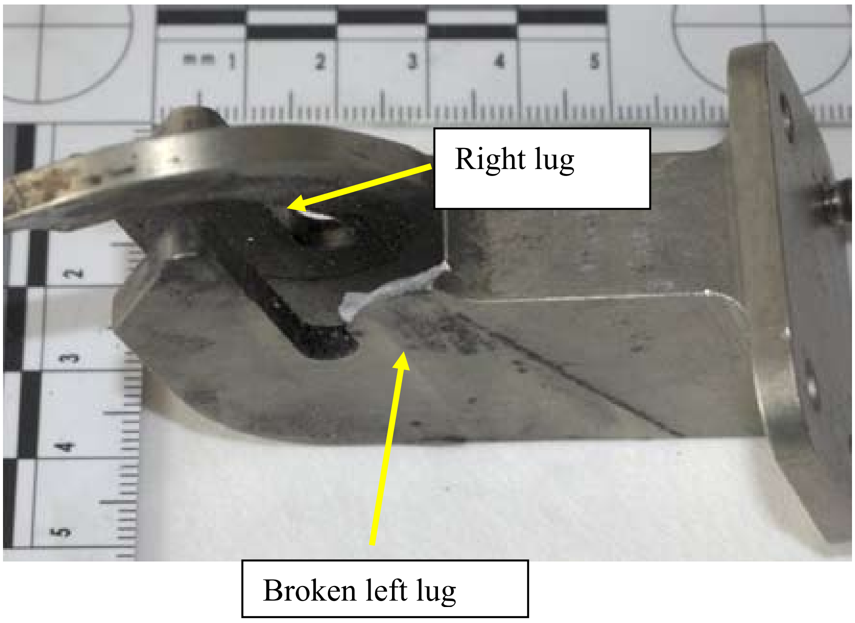


Figure 18

Hook guide

Hook and operating handle assembly

Apart from a small area of deformation, and normal wear, there was no damage on the front face of the hook, although there was an indentation across the rear face, which aligned with the shaft on the operating handle, Figure 19. The shaft on the operating handle had been pushed rearwards with sufficient force to distort the shaft and the sides of the operating handle. The 'Y' shaped bracket had also been deformed in a manner consistent with it being restrained at its aft face whilst the hook was forced into the front face. This would only be possible if the hook had withdrawn from the hook guide. All this damage is consistent with a force being applied to the hook causing it to move rearwards with sufficient force to bend the shaft and form the indentation.

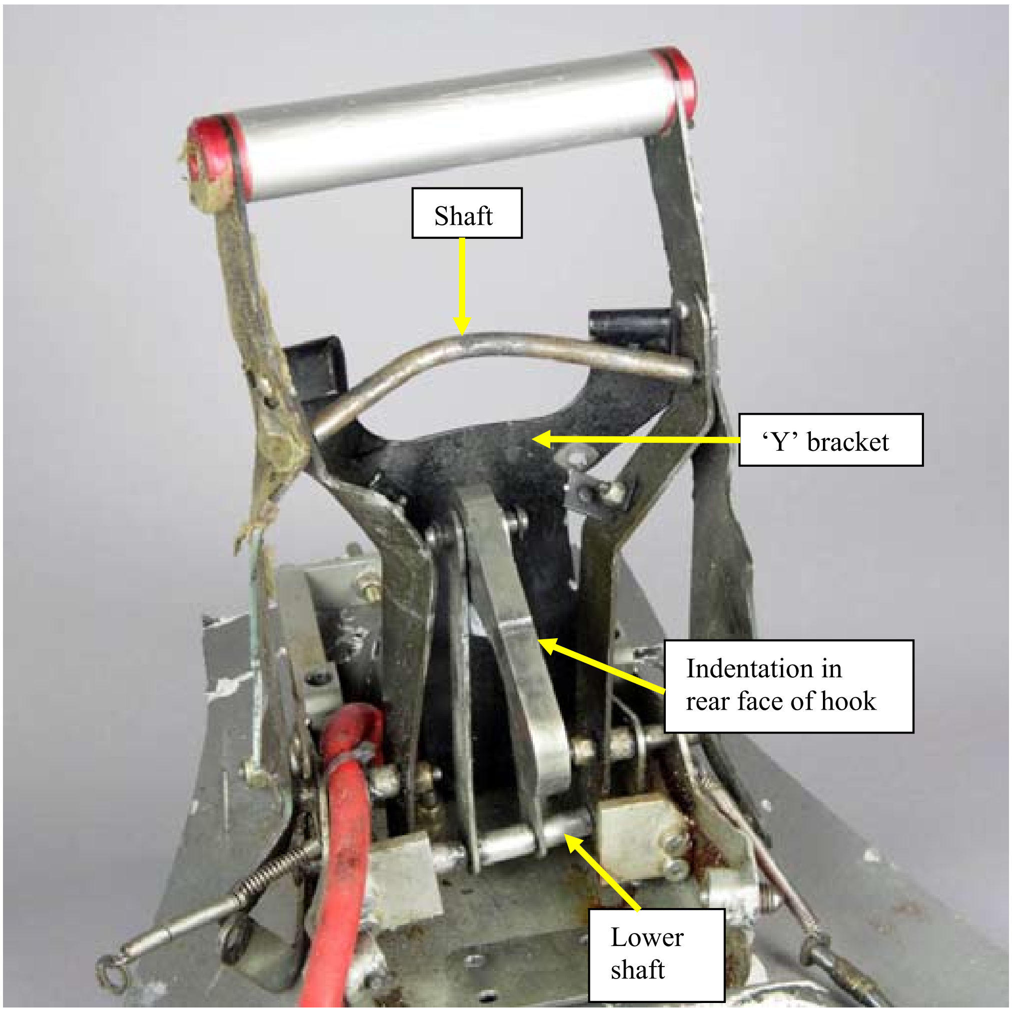


Figure 19

Damage to canopy operating handle assembly

'Jettison' handle

The left and right side of the red 'jettison' handle, where it connects to the cylindrical pins, had splayed and bent in a direction consistent with a load having been applied from the front and right side of the aircraft with the handle installed in the mechanism, Figure 20. In addition, the left steel hinge pin, which connects the cylindrical pin to the handle, had failed and longitudinal witness marks were apparent on the aft face of the right cylindrical pin. Impact and scuff marks along the bottom front face of the 'jettison' handle were also consistent with it having been subject to a large rearward force.

It was established that to fail the steel hinge pin, a force of 2,200 N (495 lbf) would have to be applied to the 'jettison' handle. Moreover, by testing a new handle, it was demonstrated that it would require a force of 546 N (123 lbf) to splay and bend the handle to the extent seen on the left side of the handle from G-BYXR. It would not have been possible for either the pilot or cadet to have applied such a force. However, the damage to the 'jettison' handle is consistent with it having being struck by the operating handle moving rearwards. This action would also account for the handle being found in the wreckage instead of being thrown forward with the other components from the canopy.

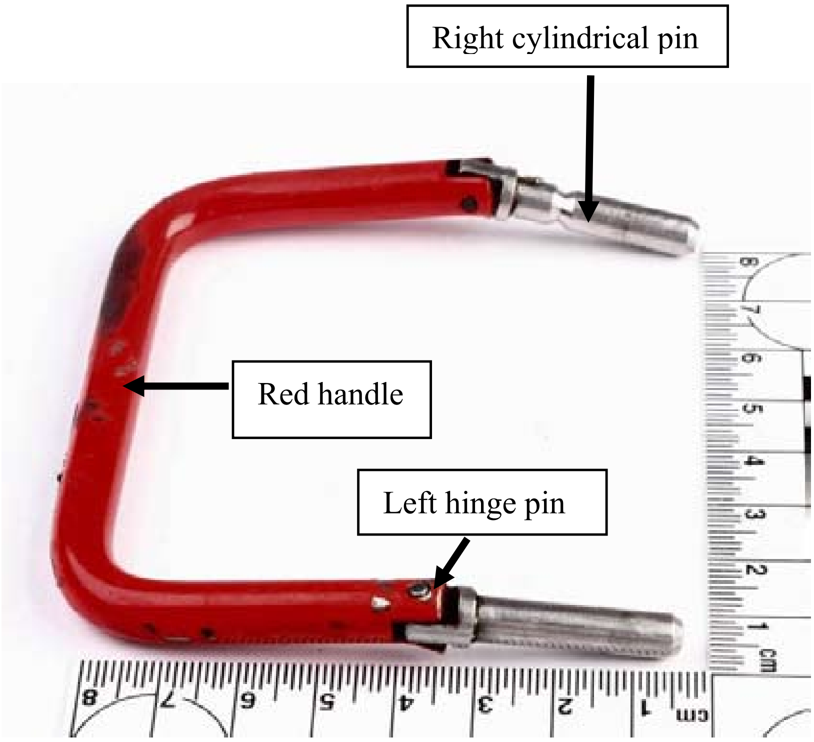


Figure 20

Canopy 'jettison' handle

1.12.5.2 Cadet's QRF

From three dimensional X-rays of the cadet's QRF, it was established that the locking mechanism, plungers and springs were all intact. The QRF had sustained some distortion, consistent with it being trapped between the control column and structure under his seat, such that the pistons that retained the male portion of the shoulder harness in the QRF could not travel to the fully engaged position. However, both pistons that retained the male portion of the lap straps had travelled through their full range of movement and would have prevented these straps from releasing during the impact.

The examination concluded that the cadet's QRF was serviceable and his harnesses had been released prior to the ground impact.

1.12.5.3 Wing structure

Both wings were reconstructed, as far as possible, at the AAIB's facility at Farnborough. Whilst the wings had been extensively damaged during the ground impact, it was established that, with the exception of the outer 1.5 m of the leading edge of the left wing, the aircraft had been complete and structurally intact prior to impact with the ground. There was no evidence of any pre-impact damage to the wing spars or damage to the wing skins aft of the front spars. By comparison with another aircraft, it was established that the 0.65 m section of carbon fibre structure found approximately 800 m from the main wreckage of the Tutor, originated from this section of the wing. This piece of structure had red smear marks on it, similar in colour to the identification marks on the glider. Figure 21 shows the location on the aircraft where the pre-ground impact leading edge damage occurred. The aircraft's pitot tube, which was not recovered, had been pulled from the lower outer section of the left wing.

1.12.5.4 Emergency locator transmitter (ELT)

While the outer casing of the ELT remained intact, the structure on which the transmitter was mounted had broken during the impact and the transmitter was found buried in the wreckage. The co-axial cable to the external aerial had pulled out of the transmitter and the D type connector had been badly damaged. No transmissions were detected from the ELT during or after the accident flight.

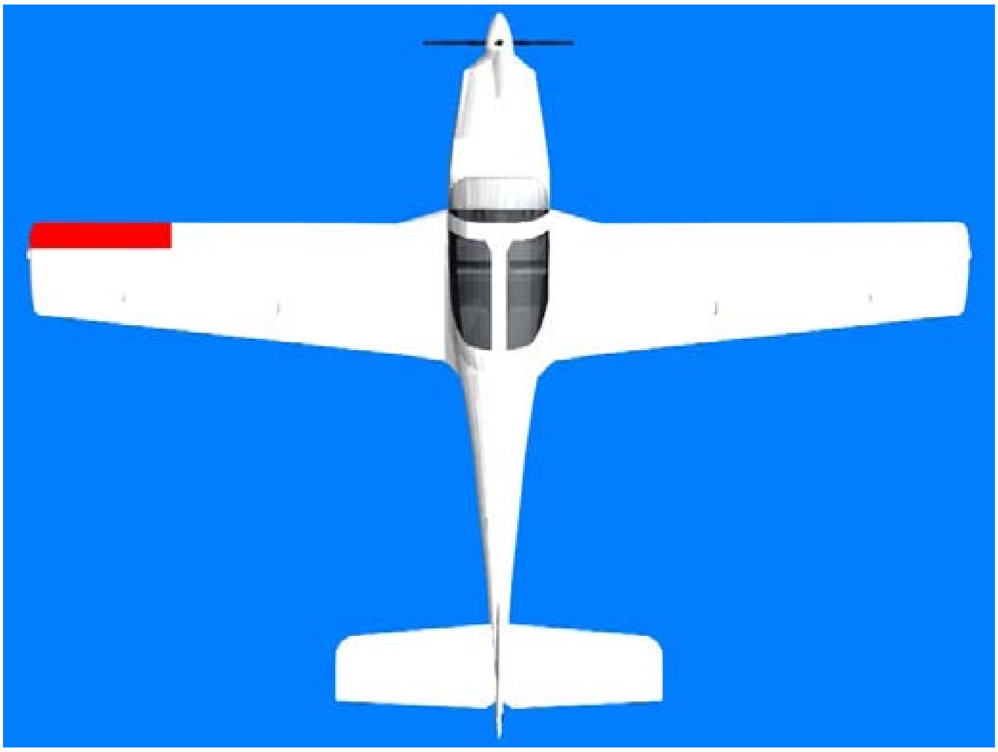


Figure 21

Area of Tutor damaged in collision, coloured red

1.12.6 Detailed examination of Glider (G-CKHT)

The left side of the fin was undamaged. The skin on the right side of the fin had been forced inwards and locally sheared where it joined a vertical spar. There were also faint black smear marks at an angle of approximately 10° to the vertical across the forward part of the fin and a puncture hole, approximately 20 mm in diameter, 74 cm from the top of the fin, Figure 22.

Detailed inspection of the glider's structure revealed no physical evidence that any part of the glider had penetrated the cockpit of the Tutor.

Figure 22

Damage to the glider's fin

1.12.7 Collision geometry

From examination of the wreckages, it was established that a 1.3 m section of the Tutor's left wing, approximately 0.2 m in from the wing tip, struck the right side of the glider's fin. During the impact, the pitot probe, mounted below the Tutor's left outer wing, punctured the fin and was torn from the aircraft. From the damage to the wing leading edge, and the geometry of the smear and puncture marks on the glider, it was apparent that it was the Tutor's lower wing skin just aft of the leading edge, which made contact with the fin of the glider. A visualisation of the collision is at Figure 23.

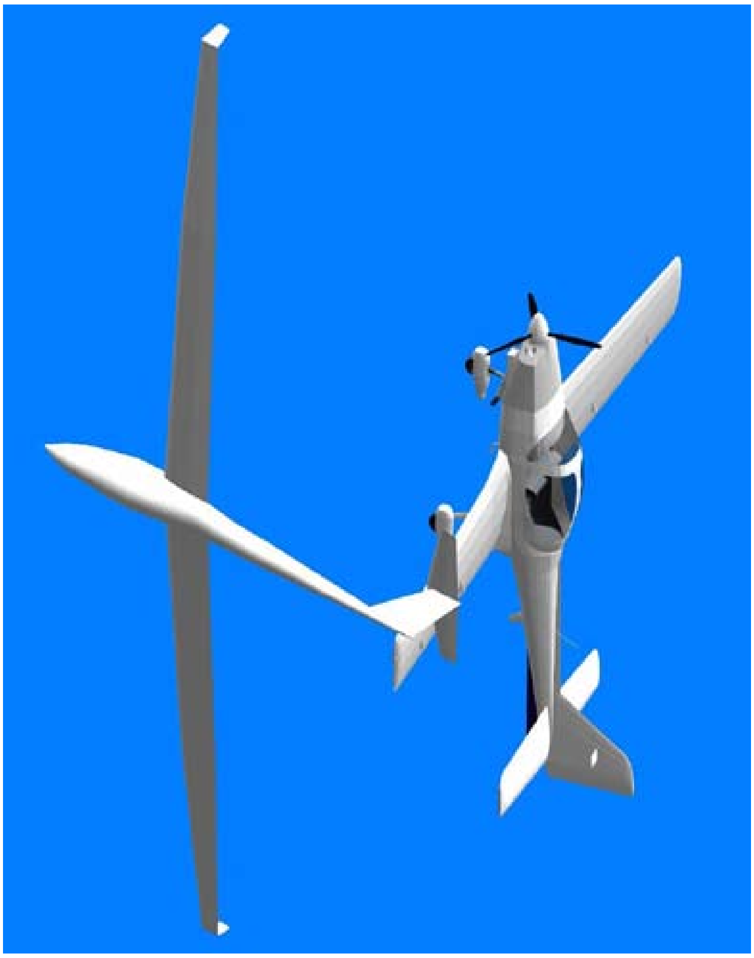


Figure 23

Visualisation of the mid-air collision

1.13 Medical and pathological information

1.13.1 General

Postmortem examinations were conducted on the pilot and cadet by an independent Home Office pathologist, observed by a specialist aviation pathologist. The aviation pathologist reported that there was no evidence to suggest that either the pilot or the cadet had consumed alcohol or any other drug likely to affect their performance.

The aviation pathologist commented that both occupants had been exposed to forces associated with the ground impact that were '*outwith the limits of human tolerance'*, and that *'the crash was non-survivable.*' Their injuries were judged to have been caused when the aircraft struck the ground; however, it was impossible to exclude the possibility that lesser injuries were sustained at the time of the collision.

1.13.1.1 Tutor pilot's medical history

The Tutor pilot held a current RAF A3G2Z1 medical category, which had been renewed on 5 May 2009. This medical category contained a restriction (A3) that he was not to fly ejector seat equipped aircraft. G2 and Z1 refer to ground duties, and temperature zone, and are not relevant to this accident. The pilot held, concurrently, a civilian JAA Class 2 medical, which allowed him to fly private, civil registered general aviation type aircraft. This medical had also been renewed on 5 May 2009 by the RAF MO, but the completed paperwork had not been received by the CAA, whose records showed that his Class 2 medical had expired on 20 March 2009.

The pilot's medical records show that he was required to use corrective lenses. His uncorrected vision was reported in 2009 as 6/24[4], but this was corrected to 6/6 with varifocal lenses. The remains of a set of RAF spectacle frames were recovered from the aircraft wreckage. A CAA optometrist commented that a pilot with this visual acuity would need to rotate his head to bring the appropriate region of the lenses to bear on the section of sky he wished to scan. The pilot would have had a significant degradation of vision outside the area of the lenses.

1.13.1.2 Tutor pilot's medical condition

The Tutor pilot had the condition Ankylosing Spondylitis (AS). This is an inflammatory spinal disorder, which causes fusion of the bones of the spine and results in a fixed forward stooping posture. The pilot had been regularly assessed by RAF medical specialists over many years. By 1997, his records contained notes that the specialists considered that his condition was essentially 'burnt out', with no likelihood of further deterioration.

With respect to the pilot's condition at the time of the accident, the Home Office pathologist reported:

> '*..vertebral bones are fused and the entire vertebral column is rigid.*'
>
> *'There is pathological evidence of ankylosing spondylitis with excessive forward curvature of the spine. The neck vertebrae are rigidly fused; because of the disruption of the upper cervical vertebrae I cannot assess the degree of movement that was possible*

4 6/6 would be normal distance vision; 6/24 is one quarter of the normal distance vision. The UK car driving standard is 6/12 after correction.

> *of the head or the neck. It is likely that the spinal disease limited [the pilot's] ability to turn and raise his head in order to make observations.'*

1.13.1.3 Review of Tutor pilot's medical condition

The medical terms used in this report are explained in Appendix A.

Medical records

The pathologist's report and the pilot's military medical records, provided by the MoD, were reviewed by a civilian consultant rheumatologist specialising in AS. The records included the pilot's RAF Form Medical 4 (FMed4), which is a written record of every visit to an RAF doctor and any medical intervention during the pilot's service career. Four radiographs, dated 1985, were also provided by the MoD and were reviewed by the consultant. Three of these were of the pilot's pelvic region and one of his chest. A radiograph of the cervical spine, although listed, was missing from the file. The specialist commented:

> *'we did have good access to the pelvis including the hips, and three of the films revealed fused sacro-iliac joints, normal hips and a suggestion of some ossification at the lower end of the lumbar spine……Thus, he had severe ankylosing spondylitis..'*

Until 1999 the pilot's records show at least an annual review of his AS condition by RAF consultant rheumatologists. This included measurements which allowed the progress of the disease to be tracked. A summary statement, dated 27 July 1999, states:

> *'I reviewed this man with longstanding ankylosing spondylitis. He is about to cease flying…… Examination shows that he remains grossly kyphotic but his wall to tragus distance is unchanged at 31 cms, his cervical spine has minimal lateral flexion, but rotation is approximately 50%. There is no movement in the lumbar spine. Hips move freely.'*

The civilian AS specialist commented:

> *'..cervical spine rotation relates to the anatomy between C1/C2 and is the last site to be involved in ascending spondylitis.*

> *However, that he has minimal lateral flexion suggests that he has ossification of the middle range of cervical spine vertebrae and lower range in the neck.'*

The conclusion in the medical record dated 27 July 1999 stated that he had:

> *'..severe ankylosing spondylitis but unchanged since the previous assessment. The requested flight assessment by his MO (Medical Officer) was not performed but fortunately he is now leaving the flying role.'*

The civilian AS specialist went on to state, regarding the pilot's Fmed4:

> *'..several of the comments allude to the disease being "burnt out" – a phenomenon that we no longer believe in but, of course, with such severe disease in terms of spinal mobility limitation, there can be little progression over time, but that he had no new features in terms of more eye disease, lung disease, bowel disease or peripheral joint disease enhances the concept that the disease is "burnt out".'*

Specialist review of the Tutor pilot's condition

The civilian AS specialist made the following comments after reviewing the Tutor pilot's medical history:

> *'Clearly this gentleman had very severe ankylosing spondylitis but, because it affected only the spine and rarely the left eye, in terms of iridocyclitis, he was generally fit and able to persevere with his professional activities of flying etc.*
>
> *Thus, there was relatively little systemic disease and no sinister involvement of peripheral joints – particularly the hips, or major tissues, such as pulmonary, cardiac, bowel or other organs.*
>
> *Nevertheless, we know that the spinal disease was progressive from 1970 onwards, and by the mid-1970's, he had virtually no residual spinal movement, and although I have not seen a radiograph from that time, we do know that clinically he had very little neck movement, and the post mortem clearly described total fusion of the cervical vertebrae.*

Thus, he was at great risk in terms of developing a spontaneous fracture simply because of the dramatic degree of osteoporosis or bone thinness that we recognise in ankylosing spondylitis, on the one hand, or he was at risk of developing a fracture of the cervical spine after very limited minimal trauma.

Of course, as a rheumatologist, I cannot comment on the forces that would have occurred at the impact of his aeroplane and the glider with which his plane made contact.

In terms of the vulnerability of the spine, I believe that as he was in a harness, the mechanical forces would have been even greater than would otherwise have been the case, given that there would have been virtually no spinal movement to reduce the impact of the initial trauma.

On the balance of probabilities, I believe that his cervical spine may well have fractured at the time of the initial impact, and such a fracture would have resulted in total destruction of the spinal cord, which descends from the brain to the rest of the body.

This would have resulted, naturally, in sudden death and thus, he may have lost consciousness within a second of the impact and thus, would have had no ability to control the aircraft thereafter.

Although he had good vision when corrected with appropriate lenses, I cannot imagine that he had good vision in terms of ability to look up or sideways, given that he would have had very little flexion and extension or lateral flexion of the cervical spine. He would have been able to nod to a minor degree, because by all accounts, there was still mobility at C1 to the occiput, and there would have been a minor degree of right and left rotation because it appears that the C1/C2 vertebrae may not have been fused.

Nevertheless, I find it difficult to imagine that he would have had sufficient mobility to be able to have a good field of vision – particularly in terms of a potential emergency, but I leave it to other specialists to comment further on the specifics.'

1.13.1.4 Annual medical assessment

A Medical Officer (MO) at RAF Benson conducted the pilot's medical examination in 2005 when he joined the AEF as a VR(T) pilot. He also carried out his subsequent annual medical examinations, the most recent in May 2009. Because of the pilot's AS, in 2005 the MO requested that a 'cockpit check' be conducted. This was carried out by the then commanding officer of the AEF who reported to the medical officer by letter, dated 09 March 2005, that the pilot:

> *'….could easily reach all the necessary primary and ancillary controls. Moreover I had no concerns of his ability to lookout for other aircraft: by moving his head and eyes he was able to see above the aircraft and to the rear to the outer tips of the tailplane.'*

The MO had previously conducted some cockpit checks, but commented that it was not always possible for him to be present, especially with part-time AEF pilots. The MO stated that, with regards to the pilot's AEF flying, he thought this would only involve local flying and did not consider that the pilot might perform aerobatic manoeuvres, other than loops where he would only be exposed to positive g. In the MO's opinion, the AS would possibly have restricted the pilot's ability to look above his head.

The pilot's FMed4 included a copy of a letter, dated 13 May 1997, sent from an RAF consultant in rheumatology to the CAA. The letter, in support of the pilot's application for a civil Class 2 medical, stated:

> *'…He remains of course grossly kyphotic and in certain types of aircraft would no doubt have difficulty with vertical lookout. I understand, however, that this is not relevant to his Cessna type flying or indeed to any flying role that he is likely to adopt in the military.'*

The MO at RAF Benson stated that he was unaware of the contents of this letter relating to vertical look-out and that, if he had been, he may have decided to conduct the cockpit check himself.

1.13.1.5 Tutor pilot's instructor course

Following his instructor course with 115 Sqn in 2008, the pilot's RAF Form 5000[5] was updated with an end of course report, which included the following comment:

> *'..a minor point to note is that he has to work hard to complete a comprehensive lookout scan; an aspect that he actively tries to overcome and achieve.'*

Individual sortie reports from the instructor course were unavailable, having been disposed of in the period between the end of the course and the accident.

Six of the eight instructors who conducted his course were interviewed following the accident. Two instructors could not recollect flying with the pilot and the remaining four instructors commented that the pilot could not do the full range of look out in accordance with the Central Flying School (CFS) standard.

The CO of 115 Sqn stated that the Head of the Instructor Training Flight brought the matter to his attention and a meeting was held with the pilot to discuss his ability to conduct an effective look-out. The CO stated that he had been assured by the pilot that he could compensate for his restricted head movement. The CO, therefore, decided that as the pilot held an appropriate medical category, and was not in his chain of command, a comment on his flying record would be sufficient to alert his flying supervisors.

None of the instructors reported having any significant concerns about the pilot's handling ability, airmanship or flying instructional technique. The pilot completed the course with a high average assessment.

1.13.1.6 Traumatic spinal cord injury risk

The ankylosed spine is prone to fracture after minor trauma, due to its changed biomechanical properties.[6] The increased risk for an AS patient of a particular trauma causing a traumatic spinal cord injury (SCI) has been assessed as at least four[7] times greater than the general population with the majority of these fractures being at the cervical level (84%). However the absolute risk remains very low.

5 Record of flying training.

6 Spinal fractures in patients with ASD; a systematic review of the literature on treatment, neurological status and complications. Westerveld, Verlaan, Oner; Eur Spine journal (2009) 18:145-156.

7 ibid

The pilot's RAF medical records contain one reference related to this vulnerability. An entry dated 3 February 1976 stated:

> *'It was agreed that (in consultation with MRU Headly Court) he should not undergo parachute drills involving falls on the mat in the gym because of the risk of pathological fracture in the vertebral column.'*

1.13.1.7 Military medical standards

Royal Air Force

RAF assessment of fitness to fly is outlined in AP1269A (RAF Manual: Assessment of Medical Fitness).

Individuals with AS are not currently permitted to join the RAF, however, the Tutor pilot's condition developed after he joined the service and had qualified as a pilot. The paragraphs in AP1269A, regarding AS, include the following statements:

> *'**Clinical Concerns**. ……significant spinal rigidity, particularly cervical, can cause restriction in all round vision…..emergency egress from both vehicles and aeroplanes may be compromised…'*
>
> ***'Aircrew**… persistent symptoms may require specific aircraft type limitation…'*
>
> ***'Discussion**. ….a rigid (ankylosed) osteoporotic spine is susceptible to fracture…'*

United States Airforce

There is a comment in the United States Air Force (USAF) guidance for AS that, of 42 aviators referred for evaluation, 33 were ultimately granted waivers to continue flying with AS. It also notes that specific waiver criteria do not exist; each case would be considered individually.

1.13.1.8 UK CAA

The UK CAA commented that dealing with pilots with diseases such as AS was a core function of the Aviation Medical Department. As disease progression in AS was so variable, each case had to be treated on an individual basis in which the pilot's intended type of flying (commercial or private) would be considered.

As a general rule the CAA considers that the acceptable risk of incapacitation for single pilot public transport operations is in the order of 0.1% per annum and for multi-pilot public transport operations it is 1% per annum.

Following this accident the CAA reviewed the medical policy supporting the civil standards used for managing AS. The probability of spontaneous fracture was considered to be below the 0.1% level. However, the risk of fracture following trauma is increased in individuals with significant AS.

The CAA policy on cockpit checks would require a pilot flying single pilot public transport operations to be assessed by a CAA Flying Unit (CAAFU) examiner. A private pilot could be checked by a CAA approved Flying Instructor (Examiner) (FI(E)) and the CAA maintains a list of approved FI(E)s for such circumstances.

1.13.2.1 Glider pilot

The glider pilot held a current JAA Class 2 medical with no limitations. Other than some bruising, he reported no injuries from the accident.

1.14 Fire

There was no evidence of a sustained fire on either aircraft. There was evidence that a flash fire may have occurred when the Tutor struck the ground.

1.15 Survival aspects

1.15.1 Tutor (G-BYXR)

The forces experienced by the pilot and cadet during the aircraft's impact with the ground rendered this a non-survivable accident.

The occupants of the Tutor aircraft are normally secured by a five-point harness, which is released by operating the QRF. Both the pilot and cadet were wearing a military flying suit, flying gloves, a safety helmet and a lightweight parachute (EB85/1). The parachute specifications state that the minimum operating height is 500 ft agl. While the drogue on the cadet's parachute had released from his pack, the operating handle (D-ring) had not been pulled and was found in its stowage pocket.

At the time of the ground impact, the canopy operating handle was in the open position; however the canopy jettison system had not been operated. The cadet's harness straps had been released from his QRF, which was in the 'locked' position. The pilot's harness was still connected to his QRF. The chin straps on the pilot's and cadet's helmets had broken, and their helmets had come off in the accident.

1.15.2 Glider (G-CKHT)

The pilot was secured by a four-point harness and, at the time of the collision, his shoulder harness was loosely fastened.

During the collision the pilot's head struck, and broke, the acrylic material of the canopy, causing some bruising to his head. Following the collision, the glider adopted an inverted attitude. The pilot opened the canopy using the red opening knob, released his harness and rolled out of the cockpit. In addition to the bruising to his head, the pilot sustained some bruising to his lower legs during his egress from the cockpit and bruising to his torso from the parachute harness, which had not been tightly fitted.

1.16 Tests and research

1.16.1 Flight tests

A number of flight tests were conducted by the Civil Aviation Authority, on behalf of the AAIB, to:

- assess the aircraft's longitudinal static stability,
- assess the aircraft's spin characteristics,
- establish if a loose QRF could have restricted the movement of the control column and prevented the aircraft from recovering from the dive.

The flight tests, which are detailed in Appendix B, established that:

- The Tutor has sufficient positive/stable longitudinal static stability to satisfy the requirements of FAR/CS 23.175b. However, the stability was assessed as weak, particularly at higher speeds, and it was likely that in a near vertical dive the aircraft would exceed V_{NE}, and lose considerable height, before any natural tendency to pitch nose-up would have a significant effect.

- The tests established that the Tutor has very benign spin characteristics and recovers easily, as soon as pro-spin controls are released, or spin recovery action is taken. If a spin is entered at the top of a loop, with the stick free, it is likely that the aircraft would recover naturally, as long as pro-spin controls are not applied and maintained.

- A previous spinning occurrence illustrated that, whilst the CAA flight tests demonstrated that the Tutor normally recovers quickly and easily from a spin, there are situations when the aircraft will take longer to recover and will lose considerably more height than would normally be expected.

- The tests concluded that with an airspeed of 120 kt, or above, a control restriction, resulting from a QRF and crotch strap becoming jammed between the control column and structure beneath a seat, would have had negligible effect on the aircraft's ability to recover from a dive.

1.16.2 Possibility of the cadet restricting the movement of the control column

A test was conducted to establish if, after releasing his harness, the cadet might have fallen forwards and restricted the rearwards movement of the control column. The tests concluded that even if the cadet had fallen forward, there would probably still have been enough space for the pilot to move the control column rearward sufficiently to recover the aircraft from a dive.

1.16.3 Independent aerodynamic investigation

Specialist advice was sought from QinetiQ as to whether there was sufficient aerodynamic performance available to recover the aircraft following the mid-air collision. In assessing the effect of the damage sustained in the collision, QinetiQ ran two computer simulations: the first used a flat plate model of the wing planform and the second analysed the two-dimensional aerofoil properties of the wing.

The first simulation considered the effect on the asymmetric rolling moment incurred through the loss of the outer 1.5 m section of the left wing using the same aspect ratio, sweep and taper as the Tutor wing. This simulation considered the worse case scenario of a cropped wing undergoing a roll manoeuvre with only a right aileron for control and no beneficial damping from the rear fin and tailplane.

The second simulation evaluated the Tutor's aerofoil properties using data supplied by the aircraft manufacturer. From this data, and the wing setting angle, the wing zero lift angle was derived and the effect of this on the angle required to achieve zero rolling moment was assessed.

QinetiQ reported that the evidence from their aerodynamics investigation suggests that sufficient roll control power existed, following the collision, to trim an estimated worse case rolling moment at low to moderate angles of attack.

1.16.4 Human Factors review

A human factors expert, with considerable experience of mid-air collision investigation, conducted an assessment of a pilot's ability to detect the glider.

The expert reported that it is generally acknowledged that gliders can present a significant challenge to the see-and-avoid principle of collision avoidance. It was possible for him to estimate the likely effectiveness of visual look-out in this accident, using a computer modelling programme originally developed to consider the effectiveness of the see-and-avoid principle in fast jet operations[8]. A limitation of the programme is that it was designed to work with both aircraft at the same height, using the contrast of the target aircraft against the horizon. The simulation was stopped at 10 seconds prior to the collision, when the height difference exceeded the limitations of the model. A further limitation was that the model did not take into account the possible obscuration of the glider by the Tutor's windscreen and canopy arches.

It was not possible to establish if the sun was obscured by cloud at the time of the accident, so the model was run using two levels of illumination. In one, the glider was in direct sunlight (direct illumination) and in the other the cloud obscured the sun (indirect illumination). The models showed that the glider exhibited a lower contrast, ie was more difficult to detect under direct illumination than indirect illumination.

8 (a) Chappelow, J W and Belyavin, A J. 1991 Random Mid-Air Collisions in the Low Flying System IAM Report #702 RAF Institute of Aviation Medicine, Farnborough Hants.
(b) Chappelow, J W, Belyavin, A J and Smith P R, 1993 Aircraft Conspicuity and Paint Schemes; A Further Trial. IAM report # 747 RAF Institute of Aviation Medicine, Farnborough Hants.
(c) Chappelow, J W, Belyavin, A J, Ruskell, L, Procopides, M, Smith, P R, and O'Connor, E M, 1997. See-and-Avoid Operational Analysis Study. PLSD/CHS/HS3/CR97029/1.0. Centre for Human Sciences, DERA, Farnborough, Hants.

The model established that, 40 seconds prior to the collision, the glider would have been effectively invisible to the human eye. The probability of detection would increase to 50% at 25 seconds and 95% at 10 seconds prior to the collision, Figure 24.

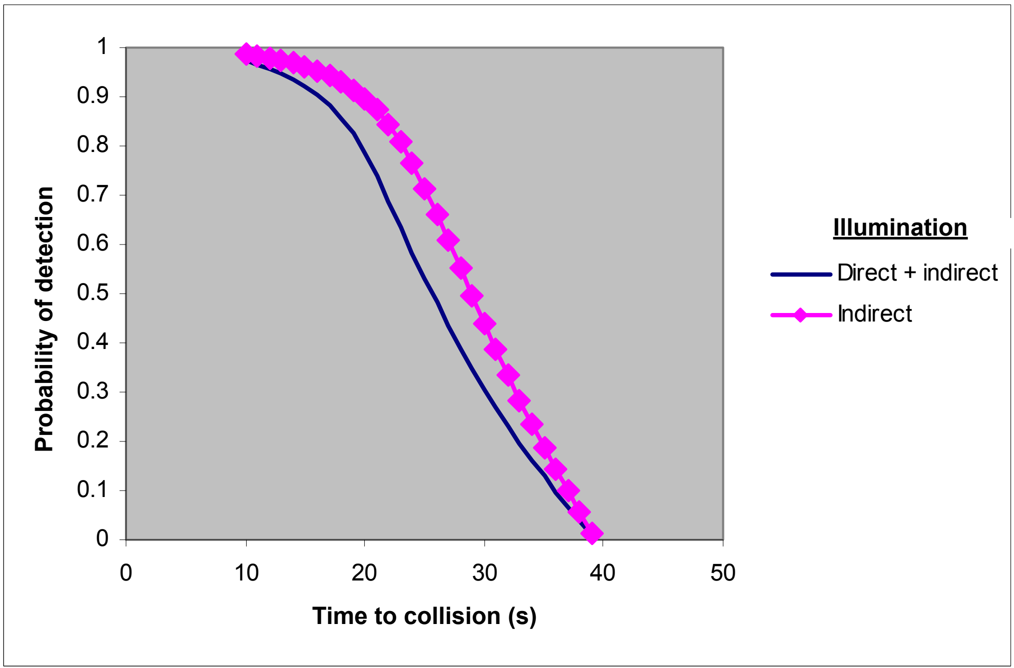


Figure 24

Probability of detecting the glider

The expert concluded:

> *'See-and-avoid is not perfect. There is always a residual risk of failure to detect in time to avoid the collision. In this case, the residual risk appears to have been relatively small. That is, given normal visual scanning, there was a reasonable chance of detecting the glider in time to avoid the collision.*
>
> *This suggests that the Tutor captain's scanning may have been compromised by distraction (e.g. by other potential threats), by his restricted head mobility, or by some other factor.'*

1.17 Organisational and management information

1.17.1 Air Cadet Organisation

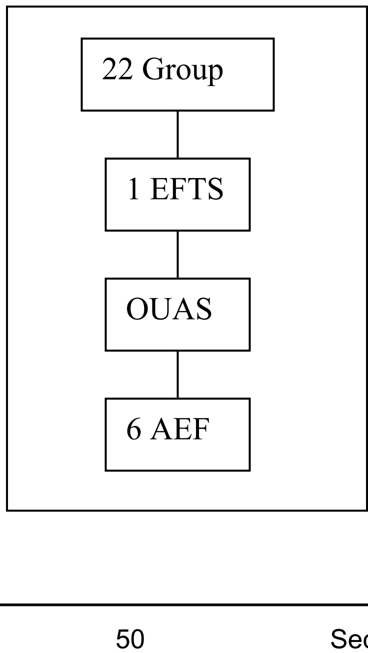
The Air Cadet organisation offers cadets the opportunity to undertake at least one air experience flight per year. These flights are conducted by pilots on the RAF's AEF, who are not required to be instructors. The flights are not conducted for 'hire or reward', nor are they classed as instructional flights. There is no direct civil equivalent and similar flights would probably be classed as instructional flights or public transport passenger operations where stricter regulations apply.

1.17.2 Air Experience Flights

The RAF's air experience flying take place within the UAS structure under the command of the Officer Commanding 1 Elementary Flying Training School (1 EFTS). 1 EFTS is part of 22 (Training) Group RAF and responsibility and authority to operate devolves from the Air Officer Commanding 22 Group and, ultimately, from the Secretary of State for Defence.

6 AEF operate out of RAF Benson and in order to achieve their task of flying 6,000 to 8,000 air cadets per year, the average flight had been set at 20 to 25 minutes.

At a local level, the AEF pilot was one of around 45 available to 6 AEF. His immediate supervisor was the flight commander of 6 AEF who reported to the Officer Commanding (OC) Oxford University Air Squadron (OUAS). From OC OUAS the chain of command passed to 1 EFTS at RAF Cranwell.



1.17.3 Inspection of 6 AEF by HQ 1 EFTS

Prior to the accident, OUAS (incorporating 6 AEF) was inspected by staff from HQ 1 EFTS on 11 May 2009. Standards were found to be generally high, although there were some minor discrepancies in paperwork. The inspection report stated that OC OUAS had flown with all the staff instructors, with the exception of the accident pilot, who had been unavailable.

The inspection report made the following comments regarding changes implemented since the previous Tutor mid-air collision in February 2009:

'OUAS/6 AEF have implemented measures to deconflict flights; these include operating under a Traffic Service when available; sequencing of air cadet sorties on standard routes in minimum weather conditions; and the identification and use of Visual Reference Points within the normal operating area.'

The report concluded:

'As with all UASs, OUAS find themselves short of manpower and stretched. Notwithstanding this, OUAS have shown a commendable focus on the flying aspects of UAS activity and should be congratulated on their achievement; as should the AEF. While this air staff inspection discovered some anomalies these were of a minor nature and my suggestions were taken with good grace. Flying operations are in good hands and need cause you no concerns.'

1.18 Additional information

1.18.1 Certification of canopy jettison system

Certification of the canopy jettison was undertaken by the LBA to FAR 23, amendment 32, which is equivalent to CS 23[9]. CS23.807 (b) and (c) state:

9 CS23 – Certification Specification for normal, utility, aerobatic and commuter category aeroplanes.

> *'23.807 (b) ……In addition, each emergency exit must –*
>
> *(1) Be readily accessible, requiring no exceptional agility to be used in emergencies;*
>
> *(2) Have a method of opening that is simple and obvious;*
>
> *(3) Be arranged and marked for easy location and operation, even in darkness;*
>
> *(4) Have reasonable provisions against jamming by fuselage deformation;*
>
> *(5) In the case of aerobatic category aeroplanes, allow each occupant to abandon the aeroplane at any speed between V_{SO} and V_{DO}[10];*
>
> *(6) In the case of utility category aeroplanes certified for spinning, allow each occupant to abandon the aeroplane at the highest speed likely to be achieved in the manoeuvre for which the aeroplane is certificated*
>
> *23.807 (c) Tests. The proper functioning of each emergency exit must be shown by tests.'*

To support the certification of the Grob 115E, the LBA used the manufacturer's test report for the in-flight jettison of the canopy on the G115 TA (test aircraft). During the tests, the front canopy guide blocks were replaced with ones fitted with longer retaining pins; the rear canopy guide block was unchanged. The canopy jettison was then tested in-flight, by sliding the canopy rearwards a sufficient distance to disengage the forward and rear spigots from their respective bushes. The front of the canopy could then be pushed upwards until its movement was stopped by a nut fitted to the end of the retaining pins.

The tests established that the canopy could be moved easily rearwards a sufficient distance to release the spigots (about 4 cm) at speeds up to 100 KIAS, when the air pressure would cause the canopy to lift off the guide blocks. It was noted that a slight increase of effort was needed as the speed increased. No tests were carried out beyond 100 KIAS and the assumption was made that the force required to jettison the canopy was acceptable, assuming an increase

10 V_{DO} is the maximum design operating speed which for the Tutor is 1.1 V_{NE} or 205 kt.

of force required with speed. The tests did not consider the force necessary to fully open the canopy at high speeds, or the difficulty of opening the canopy in a spin or steep dive.

1.18.2 Tutor abandonment procedures

Tutor Flight Manual

In accordance with Section 2 of the Grob G115E Flight Manual[11] a placard with the following instructions was fitted behind the canopy jettison handle.

CANOPY JETTISON
1. PULL RED HANDLE AND DISCARD
2. PULL CANOPY HANDLE THROUGH 180°
3. PULL CANOPY BACK AND PUSH UPWARDS

Under the section on emergency procedures the flight manual states:

ABANDONING THE AIRCRAFT BY PARACHUTE CANOPY EMERGENCY RELEASE	
1. Engine	*SHUT OFF*
2. Red locking lever	*PULL*
3. Open canopy handle and move it backwards and up through the 90° position as far as the stop (approx 170° position)	
4. Push the canopy simultaneously backwards and upwards	
5. Safety harness	*RELEASE*
6. Cockpit	*ABANDON*

11 Document Number 115.PO.025-E.

It should be noted in this section of the flight manual the 'red jettison handle' is referred to as the 'red locking lever'.

Supplementary instructions from No 1 EFTS

On 19 March 2009, the Officer Commanding Standards Flight at 1 EFTS wrote to all EFTs and UAS squadron commanders concerning what he described as *'a poor understanding throughout 1 EFTS of how to jettison the canopy of the Tutor'*. The letter provided a comprehensive explanation as to how the canopy operating and jettison system worked. The instructions in the letter gave the following sequence of events for the jettison of the canopy:

- *'The first action is to pull the red jettison handle straight down avoiding any side or twisting moment. The handle needs to be pulled completely out.*
- *Move the canopy operating handle fully rearwards, which will pull the pins clear of the guide blocks.*
- *Slide the canopy rearwards, using the grab handles, by at least 3cm to release the 4 locking pins from the airframe. At normal speeds it should not be necessary to push the canopy away but this action may be required.*
- *To prevent a broken or dislocated arm resulting from the canopy sliding rapidly rearward it must be opened using the pilot's 'inboard' arm travelling across the body. The arm closest to the grab handle should not be used.'*

The letter also stated:

'It has been found that when trying to open the canopy in flight to practise the 'Fumes in the Cockpit' drill, a large rearward force is required to open the canopy sufficient to achieve the ventilate position, let alone the fully open position'

The Fumes in the Cockpit Drill is detailed on Card 12 in the Pilot's Flight Reference Cards. This states that the speed should be reduced below 80 kt and the canopy opened. If the speed is above 80 kt then the canopy should be set at the ventilation position[12].

12 The ventilation position is achieved by opening the canopy, at or below 80 kt, returning the handle to the locked position and then sliding the canopy forward until the latch rests against the locking bracket. The aircraft may then by flown at speeds up to 100 kt with the canopy in this position.

The letter also stated that a recommendation will be made to HQ 1 EFTS to make the abandonment drill a three monthly requirement and that this is to include a viewing of the relevant part of the safety brief (passenger video). It would also be recommended that it would be 'advantageous' for all Tutor aircrew to observe the actions required for jettisoning the canopy as an annual ground Basic Training Requirement (BTR).

1.18.3 Tutor passenger safety brief

The Tutor passenger safety brief includes a video presentation that lasts for just under 13 minutes. The video contains relevant safety information, preparation for the flight and what will happen during the flight. The passengers are advised that they can assist the pilot by looking out for other aircraft and informing the pilot of any they see. There then follows a two-minute section covering abandonment of the aircraft with it in a stable level attitude and the passenger climbing out onto the wing. The salient points covered are:

- Emergencies are very rare and having to abandon an aircraft in the air is statistically very unlikely,
- The pilot will give the order to abandon the aircraft by saying "*Jump, Jump*",
- The pilot will jettison the canopy by pulling the red canopy jettison handle,
- The pilot will open and pull back the canopy using the canopy handle,
- The passenger should positively identify their seat harness QRF and turn it either direction by 90°.

From the video presentation, it might not be obvious to the cadets that the QRF on their harness should only be released after the canopy has been jettisoned. The video also makes no mention of having to use the inboard hand to slide the canopy rearwards, or the existence of a hammer which might need to be used in an emergency if the canopy is jammed after a crash landing.

1.18.4 Cadets' understanding of the canopy jettison system

Following the accident, nine cadets who had flown that day were interviewed to ascertain their understanding of the abandonment procedures. The cadets were aged between 13 and 16 years and were interviewed by Thames Valley Police's 'young and vulnerable' witness team. In summary the interviewees variously said:

- to release the canopy, he would have to pull on the red emergency bar,
- he did not know how to jettison the canopy,
- when the big red handle is pulled the whole of the top comes off,
- they (2) were confident of being able to abandon the aircraft, although the police did not ask them to describe what actions they should take,
- the pilot will jettison the canopy by pulling a red handle,
- the instructor will pull the red lever to release the canopy,
- the video explained how you open the canopy by pulling on a lever but he would not know how to do it,
- the briefing tells you what to do and involves pulling a handle to jettison the canopy, which the pilot would normally do, but felt he could do it if he had to.

1.18.5 Use of a Traffic Service

Following the collision involving the two Tutors in February 2009, HQ 1 EFTS issued the following instruction:

> *'..operating under a traffic service (TS) will greatly aid situational awareness. Where a TS is available and sortie profiles allow, all air cadet sorties are to be conducted under a TS.'*

All UASs, which are the parent units for AEFs, were to report back by 20 April 2009 as to how this requirement had been implemented and how it was working in practice. All units complied with this requirement.

On 15 April 2009, RAF Air Command sent an e-mail to RAF ATC providers stating that that the increased use of a Traffic Service by 1 EFTS aircraft was having a significant impact on the ability to provide a radar service. The e-mail included the following statement:

> *'22 Gp are now in the process of clarifying the guidance to aircrew that the mandate is to make '**greater use is made of the radio and/or ATC**'. This still **could** be by requesting a TS or possible simply by monitoring ATC on a more continuous basis…'* [original emphasis].

Both these e-mails were included in a folder known as the 'red book' held by the AEF at RAF Benson. The purpose of this folder was to provide aircrew with the latest safety information.

Following the trial period, OC OUAS reported that operating with a full-time traffic service was impractical. The density of traffic in the Benson area required constant radio communications, which made instructing difficult and disjointed. The service was also degraded by controller workload during busy periods and pilots could not rely on it. The 'general handling' nature of AEF and UAS flying also resulted in difficulty for the controller in predicting the Tutor's flight path, and hence, assessing the likelihood of potential conflicts.

HQUAS conducted a review of the availability of traffic services for the UAS and AEF aircraft, and it was established that most of the AEFs had reported significant issues utilising a radar service, mainly due to controller workload.

1.18.6 RAF Brize Norton Lower Airspace Radar Service (LARS)

RAF Brize Norton LARS covers a radius of 60 nm centred on RAF Brize Norton, and is in operation between 0800 hrs and 1600 hrs during summer time, seven days a week. Typically, they can provide a service for up to eight aircraft simultaneously; three aircraft can receive a Deconfliction Service and five other aircraft radar services, such as a Traffic Service.

1.18.7 Aeronautical Information Circular (AIC) Y15/2009

AIC Y15/2009 explains the procedure for notifying the CAA of unusual aerial activities that may require airspace coordination, or notification, to other users. It quotes many types of activity, including a concentration of aircraft that is significantly greater than normal, air shows, displays, races and other competitions. Moreover, the AIC states that if an activity involves more than

100 aircraft, it is essential that discussions are initiated with the CAA at least 90 days prior to the activity.

1.18.8 Monitoring of traffic density

RAF Benson is located within the Oxford Area of Intense Aerial Activity (AIAA).

In order to ascertain the likely traffic density in their area, the AEF flight commander routinely telephoned all local airfields, and enquired about planned activity. In addition, RAF Benson ATC monitored NOTAMs in order to highlight possible 'high density' days in the local area. When it was felt that traffic density was too high, OUAS would routinely restrict solo UAS students from leaving the RAF Benson circuit.

1.18.9 Mid-air collisions

1.18.9.1 UK mid-air collisions between June 1999 and June 2009

The CAA database was interrogated for records of mid-air collisions that had occurred within the UK in the 10 year period prior to this accident. Eighteen accidents were identified, of which 11 resulted in one or more fatalities totalling 24 fatalities, including this accident.

For aircraft under 5,700 kg, a GASCo study over a 26 year period has shown that in the UK only 6% of fatalities were caused by mid-air collisions. This compares with almost 25% attributed to loss of control in VMC and 12% caused by controlled flight into terrain.

1.18.9.2 The UK Airprox Board (UKAB)

An Airprox is a situation in which, in the opinion of a pilot or a controller, the distance between aircraft, as well as their relative positions and speed, have been such that the safety of the aircraft involved was or may have been compromised.

An airprox is categorised into one of four categories (A, B, C, D). The two highest categories are:

Cat A. Risk of Collision - an actual risk of collision existed.

Cat B. Safety not assured - the safety of the aircraft was compromised.

The UKAB publishes an annual review of general aviation airprox reports. This includes an attempt to quantify the rate of Cat A and B occurrences, although such calculations are complicated by the difficulty in accurately estimating the number of hours flown by GA aircraft.

While the data shows a general decreasing rate of Cat A and B occurrences, there were still almost 40 Cat A or B occurrences in 2008 which involved GA aircraft. By contrast, the 2008 data contains no Cat A and only two Cat B occurrences for Commercial Air Transport aircraft (CAT).

The UKAB reported that approximately 70% of airproxes occur in Class G (uncontrolled) airspace. The risk for GA aircraft is reported as being over 20 times that of CAT aircraft, with 2.89 Cat A or B airproxes occurring for every 100,000 hours flown.

1.18.9.3 Previous UKAB Safety Recommendations

Following a Cat A airprox in October 2005, between a Duo Discus glider and a Tornado F3, the UKAB recommended that:

> *'The MOD and the BGA should examine the merit of introducing a two way information flow system that will alert each other of significant planned flying activity' UKAB 186/05-01*

As a result of this recommendation, the RAF improved liaison between Air Command and the BGA with the intention of generating 'late warnings' of gliding activity to military operators. A glider pilot, who is also a civilian fast jet test pilot, routinely briefs RAF personnel on the likely locations for fast jets to encounter gliders. The UKAB consider this recommendation 'Closed – Acceptable response'.

The UKAB also recommended that:

> *'The CAA should continue to promote and with renewed urgency the production of a "lightweight" transponder and, when available consider mandating its carriage and use in gliders.' UKAB 186/05-02*

The UKAB reported, in December 2007, that work on low-powered secondary surveillance radar transponders was ongoing, but that firm commitments would depend on CAA regulatory changes to transponder carriage and operation. The UKAB consider this recommendation 'Closed – Acceptable response'.

1.18.9.4 Previous AAIB Safety Recommendations

Following mid-air collisions involving two gliders in April 2004 and a helicopter and microlight aircraft in July 2004, the AAIB issued the following Safety Recommendations to the CAA:

> **Safety Recommendation 2005-006**. It is recommended that the Civil Aviation Authority should initiate further studies into ways of improving the conspicuity of gliders and light aircraft, to include visual and electronic surveillance means, and require the adoption of measures that are likely to be cost-effective in improving conspicuity.

The CAA rejected this recommendation. In their response they stated that '*…it is considered most practicable at this time to enhance publicity of the risk of collision through poor or inadequate visual outlook*.'

> **Safety Recommendation 2005-008**. It is recommended that the Civil Aviation Authority should promote international co-operation and action to improve the conspicuity of gliders and light aircraft through visual and electronic methods.

The CAA rejected this recommendation insofar as it was directed to light aircraft for the same reasons given in their response to Safety Recommendation 2005-006. At the time, the CAA stated that they had no regulatory power to require adoption of the recommended measure by gliders.

In 2008 the CAA proposed to widen the mandatory carriage of Mode S transponders to the majority of the aviation community. Following a public consultation exercise, the CAA withdrew this proposal and instead introduced small volumes of airspace where transponder carriage would be mandatory.

1.18.9.5 Previous Airprox

Following a Category A airprox over the RAF Brize Norton CTR on 1 June 2009 (ref: UKAB 2009-044), the UKAB commented that the Oxford AIAA is not only a busy sector of airspace, but it is complicated by the nature of the local controlled airspace that funnels traffic overhead RAF Brize Norton. On that occasion, a TCAS equipped RAF C-17, operating in

CAVOK conditions and receiving a traffic service from RAF Brize Radar, was involved in an airprox with a civil light aircraft operating a mode A, C and S transponder. Despite these aids, the recorded separation was under 100 ft vertically and 0 ft horizontally.

1.18.10 Glider conspicuity

Gliders can be difficult to see because of their aerodynamically efficient design and low visual cross-section. They are commonly coloured white and have a relatively low radar cross-section, which reduces the likelihood of them being detected by primary radar. Gliders are not required to carry transponders and radar controllers find it difficult to track an individual glider. They are often able to detect clusters of gliders when, for example, circling in a thermal to gain altitude.

1.18.11 See-and-avoid

Various studies have highlighted the limitations of the see-and-avoid method of preventing mid-air collisions. One of the most comprehensive of these was conducted in the 1990s by the Australian Transport Safety Bureau (ATSB). The Service Inquiry into the loss of the two RAF Tutors in South Wales also conducted a wide ranging review of the issues surrounding the use of see-and-avoid. It is not intended to replicate that work in this report.

1.18.12 Alerted see-and-avoid

In 1991, a report was published by J W Andrews of the Massachusetts Institute of Technology (MIT), which detailed a series of flight tests conducted to measure air-to-air visual acquisition performance for pilots employing unalerted visual search techniques. These tests were used to validate a mathematical model of visual acquisition and the results were compared with previous tests utilising a version of TCAS to provide traffic alerting. These tests determined that one second of alerted visual search is as effective as eight seconds of unalerted search[13].

13 Unalerted Air-to-Air visual Acquisition Andrews MIT 1991 Project Report ATC-152.

1.18.13 RAF Tutor Training Manual - look-out technique

The RAF Tutor Training Manual defines the look-out technique to be taught as follows:

> *'Lookout to the front and scan above and below the horizon, then attitude and instruments…. Move the eyes around the horizon in a series of steps (normally to the right initially), scanning up then down at each point…..continue the scan back to the tailplane and then look above and behind over the top and back to the front.'*

2 Analysis

The mid-air collision occurred in the Oxford AIAA, in uncontrolled airspace between the RAF Brize Norton CTR and the RAF Benson ATZ. The weather conditions were excellent, with the visibility greater than 25 km. Given the time of day, and the headings of both aircraft, the sun would probably not have affected either pilot's ability to see the other aircraft.

The examination of the wreckages showed that both the Tutor and glider had been serviceable and no pre-impact defects were present in either aircraft. Both aircraft had been correctly maintained and were within their prescribed weight and balance limits. The pilots were appropriately qualified, experienced and in current flying practice. Both pilots held the required medical certification, although the Tutor pilot had a long term medical condition, Ankylosing Spondylitis. This not only restricted the movement of his head, but also put him at an increased risk of incapacitation from relatively minor impacts.

2.1 Mid-air collision

2.1.1 Events preceding the collision

The Tutor pilot had completed two flights, each of approximately 25 minutes duration, and was engaged in his third flight providing air experience for cadets.

After departing RAF Benson and having passed Abingdon, the aircraft made a series of turns, before rapidly climbing and descending. Although the actual roll, pitch and yaw attitude of the aircraft cannot be determined, from the radar information it is probable that these manoeuvres were a wingover followed by a loop. Upon exiting these manoeuvres, the Tutor made a left turn onto an almost easterly track. At this time, the Tutor and glider were about one minute from the collision, with the glider at a similar altitude and positioned approximately 1.8 nm and 30° to the right of the Tutor's track. At this range and in these light conditions, it was unlikely that any pilot would have seen the glider.

As the aircraft closed to within one nm, about 45 seconds before the collision, changes in the Tutor's speed and altitude profiles were consistent with it performing a second loop. The Tutor exited this manoeuvre 30 seconds before the collision, at an altitude below that of the glider, before climbing to slightly above the glider. The glider remained at an almost constant relative bearing of about 30° from the Tutor. At this time the glider may have been masked by the canopy frame and, therefore, the Tutor pilot, who was sitting in the right seat, would have needed to have moved his head in order to look around this obstruction. The aircraft were still approximately one nm apart and the probability of the Tutor pilot detecting the glider was around 30% to 50%.

16 seconds before the collision, the Tutor started to descend and accelerate, and the glider, as seen from the Tutor, would have moved upwards and aft relative to its earlier position. The probability of detection would have been greater than 90%.

At 6 seconds before the collision, when the aircraft were around 230 m apart, the glider pilot saw the Tutor below and to his left. For the Tutor pilot, the glider would have been above him and to his right. Immediately before entering any manoeuvre, it is normal practice for a pilot to ensure that the area is clear of other aircraft. This would have required the Tutor pilot to tilt his head backwards to see around the obstruction of the canopy frame. The medical evidence, however, indicates that it is highly unlikely that he would have been able to do this.

The glider was maintaining a constant speed and heading until shortly before the collision. Having been alerted first by the sound of the aircraft, the glider pilot was able to look for, and visually acquire, the Tutor. It initially appeared to him that the Tutor would pass below the glider but, it then pitched up towards him. The glider pilot instinctively attempted to avoid the collision by pitching up and rolling right. Despite his efforts, he was unable to avoid the collision.

The glider was in a tight turn to the right with the airspeed reducing below 45 kt (close to the stall), when a 1.3 m section of the Tutor's left wing struck the right side of its fin and tailplane. From radar information, the statement from the glider pilot, and analysis of the damage to the Tutor and glider, it was determined that the collision probably occurred when the Tutor was vertical with an airspeed of approximately 80 kt. The force of the collision was sufficient to sever the tail section of the glider and cause the Tutor to yaw, to some extent, to the left. The radar data shows that the Tutor continued to ascend for at least a further 300 ft. The Tutor appeared to have sustained relatively little damage in the collision. Whilst the airflow over the outer 1.5 m of the left wing and aileron would have been disrupted, all the flying controls were found to be intact.

2.1.2 Post-collision

Following the collision the glider pilot abandoned his aircraft and descended safely to the ground. During the descent he saw the Tutor in a steep dive and his now abandoned glider spiralling towards the ground. He reported that the sound from the Tutor's propeller suggested it was at a high power setting. He also noticed blue smoke coming from the aircraft - a normal feature of the engine when operating at full power. Two witnesses at Marcham, almost 2 nm from the accident site, described the Tutor as descending in a spin, or spiral dive, until they lost sight of it when it was at a height of approximately 1,200 ft.

From the radar information and distribution of wreckage, it is estimated that the Tutor crashed between 150 m and 350 m to the north-west of the position where the mid-air collision occurred. There was no evidence of the aircraft having still been in a spin when it impacted the ground. The aircraft impacted the ground at high speed and at an angle of 70° to 80° below the horizon.

2.2 Failure of the Tutor to recover from the dive

It was established that the only part of the Tutor to be damaged in the collision was the outer section of the left wing leading edge. The investigation could not identify any reason why the aircraft could not have been recovered from either the spin or the dive. The glider pilot's account and the ground marks are consistent with the Tutor not rotating when it impacted the ground. This indicates that the damage to the left wing was not severe enough to cause the aircraft to roll uncontrollably during its descent to the ground. This assessment is consistent with the computer simulations undertaken by QinetiQ, who concluded that, following the collision, there should have been sufficient roll control available.

The investigation considered a number of possibilities for the apparent failure of the aircraft to recover after the collision. These included a study of the handling qualities of the aircraft, and the possibility of a control restriction or pilot incapacitation.

2.2.1 Handling qualities

From the tests undertaken by a CAA flight test pilot, it was established that an undamaged Tutor has very benign spin characteristics and will recover easily as soon as pro-spin controls are released. However, a previous occurrence, where the aircraft adopted a flatter attitude and a higher rate of rotation than normal, demonstrated that under certain conditions the Tutor may take longer to recover from a spin than normal. The tests also established that the Tutor has ‘weak’ longitudinal stability. It is, therefore, likely that an aircraft trimmed at 120 kt[1], in a near ‘stick-free’ vertical dive, would exceed V_{NE} and lose considerable height before any natural tendency to pitch nose-up would have a significant effect.

From radar information it was established that the collision occurred at a height of approximately 4,150 ft, and the Tutor reached around 4,500 ft before it started to descend. Over the next 4 secs, the vertical speed reached 29 m/s (60 kt), increasing to 53 m/s (104 kt) after 8 secs and 68 m/s (133 kt) after 12 secs. The final radar information was obtained after 16 secs, when the aircraft was at a height of around 1,200 ft with a vertical speed of 99 m/s (193 kt). From the manufacturer’s flight test data it was established that, in a spin, an undamaged Tutor will descend at a rate of 50 to 70 m/s (97 kt to 136 kt). The aircraft’s vertical speed profile following the collision does not match the expected speed profile of an aircraft in a near vertical dive. However, the radar information could be interpreted as the aircraft having entered, and then recovered from, a spin, followed by a near vertical dive to the ground. This is consistent with the witness accounts and the ground marks.

Had the aircraft started to recover from the spin at 1,200 ft, the height at which it was last seen in a spin / spiral manoeuvre, then there might have been sufficient height available, with the appropriate control inputs applied, for it to recover from the dive. Even with a partial recovery, the aircraft would have contacted the ground at a lower grazing angle and at a greater distance from where the mid-air collision occurred.

2.2.2 Control restriction

The investigation established that the cadet’s seat harness had been released before the aircraft struck the ground.

Consideration was given to the possibility that after the cadet released his harness, his QRF and crotch strap might have dropped down in front of his seat and caused a control restriction which prevented the aircraft from recovering from the dive. It was established from flight tests that while the QRF had the potential to restrict the control column from moving fully aft, sufficient movement remained available to enable the aircraft to be recovered from a steep dive.

1 It is normal practice for the pilot to trim the aircraft to 120 kt prior to commencing a looping manoeuvre.

Consideration was also given to the possibility that the cadet, free from his harness, fell forwards in the cockpit and restricted the rearward movement of the control column. Ground tests suggest that there would still have been sufficient control movement to recover the aircraft although the possibility that he might have restricted the rearward movement of the control column could not be totally discounted.

2.2.3 Pilot incapacitation

Following the collision, the pilot made no radio calls. The limited damage to the left outer wing of the Tutor, and the assessment that the flying controls were intact and probably not jammed prior to the ground impact, suggests that the aircraft was capable of being recovered from the dive, but no attempt appears to have been made to do so. If an attempt had been made, it would have been appropriate for the engine power to have been reduced to a minimum. However, the increasing noise from the propeller, and the blue smoke seen to come from the engine, indicates that the engine was still at high power.

It is standard procedure for the canopy to be closed and locked prior to commencing aerobatic manoeuvres. Had the pilot been unable to control the aircraft, then he would have been expected to have initiated the abandonment procedure. This would have required him to remove the red canopy 'jettison' handle before pulling the canopy operating handle rearwards through 170°. It was established from the analysis of the wreckage that, whilst the operating handle had probably been moved rearwards to the canopy open position, the 'jettison' handle had not been removed from its housing and, therefore, the canopy could not be jettisoned.

Following a previous mid-air collision between two RAF Tutors, all AEF pilots had been briefed on the correct procedure to jettison the canopy. It is, therefore, unlikely that the pilot would have attempted to jettison the canopy without first removing the 'jettison' handle. It is, therefore, more probable that it was the cadet who moved the canopy operating handle.

In summary, the evidence suggests that following the collision with the glider, the Tutor entered a spin from which it recovered, before diving steeply to the ground. There is no evidence to suggest that the pilot made any attempt to recover the aircraft and, therefore, it is highly likely that he was incapacitated in the collision.

2.3 Canopy operating mechanism

Examination of the wreckage showed that the canopy operating handle was in the open position. When the aircraft impacted the ground, the canopy would have continued to travel forwards. If the canopy operating mechanism had been in the closed position then the front of the lugs on the hook guide would have impacted and grossly distorted the canopy locking bracket. This type of damage was seen in a previous accident. However, there was relatively little damage to the locking bracket and no damage to the front of the right lug on the hook guide: the left lug was not recovered. The lack of damage to these components suggests that the canopy operating mechanism was in the open position at ground impact.

The damage to the red 'jettison' handle would have required a side force of 2,200 N which could not have been applied by either the pilot or cadet. The damage to the rear of the 'Y' bracket shows that it struck the 'jettison' handle with sufficient force to distort the bracket and it is this force which probably damaged the 'jettison' handle and dislodged it from its housing.

The damage to the hook guide could not have occurred if the hook had been in the closed position and could only have occurred after the hook had come out of the guide. This would normally require the removal of the red 'jettison' handle and movement of the operating handle rearwards past the open position. However, the shaft to which one end of the hook operating rods are connected had distorted in the impact. This would have provided sufficient movement of the operating rods to release the hook from its guide with the 'jettison' handle still fitted and the operating handle in the open position.

In summary, the evidence indicates that when the aircraft impacted the ground the red 'jettison' handle was still fitted in its housing and the canopy operating mechanism was in the open position. It was not possible to establish the position of the canopy.

2.4 Emergency egress and safety equipment

2.4.1 Tutor abandonment

The flight profile, obtained from the radar data, suggests that this was the third loop flown in quick succession. Whilst it is possible that the cadet was flying the aircraft during the third loop, it is unlikely that, given this was only his second flight in a Tutor, he would have been capable of completing the manoeuvre, or recovering from the spin.

The cadet would have been startled by the collision and would then have had to recognise, and accept, that the pilot was incapacitated. He would then be faced with the decision to abandon the aircraft and, perhaps more significantly, to make the more psychologically difficult decision to leave the pilot behind. The time from the collision to ground impact was approximately 24 seconds.

It was concluded that given the attitude, motion and speed of the aircraft, it would have been difficult for the cadet to open the canopy and abandon the aircraft in the available time[2].

2.4.2 Tutor canopy jettison

The EASA certification requirement CS 23.807 states that emergency exits must have a method of opening that is simple and obvious, and require no exceptional agility. Moreover, the occupants must be able to abandon the aircraft at the highest speed likely to be achieved in the manoeuvre for which the aircraft is certified; for the Tutor this is 205 kt (V_{DO}). However, the certification testing for the canopy jettison system on the Grob 115E was not carried out at air speeds above 100 kt.

Following the previous mid-air collision of two Tutor aircraft, RAF Standards Flight at 1 EFTS discovered that there was a poor understanding throughout 1 EFTS as to how to jettison the canopy on the Tutor aircraft. Also, police interviews with seven cadets who had been shown the safety video on the same occasion as the cadet involved in this accident showed that, to slightly different degrees, a number were unsure of the actions required to jettison the canopy; four thought that the canopy was jettisoned by pulling the red handle and a fifth did not know how to jettison the canopy.

Jettison of the canopy on the Tutor can require up to four separate actions. The term ‘jettison handle’ might be misleading and suggests that this action alone will jettison the canopy. Moreover, this description, which is used in the passenger safety video and correspondence between Standards Flight at 1 EFTS and the UAS, is not consistent with the term ‘locking lever’ which is used in the G115E flight manual and the Tutor operating manual. Therefore in order to avoid confusion as to the purpose of the red locking lever, the following Safety Recommendation is made to the Air Officer Commanding 22 Group:

2 The Tutor operating manual says that if the aircraft is spinning out of control, abandonment must be commenced by 3,000 ft agl.

It is recommended that the Royal Air Force standardise the terminology used to describe the canopy 'jettison' handle (locking lever) fitted to the Grob 115E (Tutor) in order to avoid confusion and to clarify its function.
Safety Recommendation 2010–032

The evidence suggests that the canopy jettison system on the Tutor might not fully comply with CS 23.807. Therefore, the following Safety Recommendation is made to the European Aviation Safety Agency:

It is recommended that the European Aviation Safety Agency review the certification of the canopy jettison system on the Grob 115E to ensure that it complies with the requirements of CS 23.807 with specific regard to the jettison characteristics up to V_{DO} and simplicity and ease of operation.
Safety Recommendation 2010–034

2.4.3 Tutor safety briefing

Analysis of the wreckage indicates that prior to the impact with the ground, the cadet's harness had been released and the canopy operating handle had been moved to the open position; however, the red 'jettison handle' had not been removed from its housing.

Cadets are given a group safety briefing at the start of the day and are required to have watched a video presentation, which covers the abandonment procedure, within seven days of their flight in a Tutor. On this occasion, the cadets were shown the video on the morning of the accident; however it is apparent that a number were not sure of the actions required to jettison the canopy. The safety video concentrates on the actions the pilot will take and emphasises that the cadets should carry out the pilot's instructions. The cadets were not briefed on the actions they should take if the pilot is incapacitated.

The video presentation did not make it obvious to the cadets that the QRF on their harness should only be released after the canopy has been jettisoned. The video also made no mention of having to use the inboard hand to slide the canopy rearwards, or the existence of a hammer which might need to be used in an emergency if the canopy is jammed after a crash landing. It also became apparent during the investigation that the ground crew at RAF Benson strap the cadets into the aircraft; consequently, the cadets do not have the opportunity to practise fastening and releasing their harness prior to the start of the flight.

It would, therefore, be appropriate to repeat the key points of the safety brief whilst the cadets are in the aircraft prior to the start of their flight. Therefore, the following Safety Recommendation was made on 21 July 2009 to the Air Officer Commanding No 22 Group:

> It is recommended that 1 Elementary Flying Training School of the Royal Air Force review the passenger safety brief relevant to the Grob GE115E (Tutor) to ensure that passengers are briefed on the circumstances when the harness Quick Release Fitting may be released and the procedure to operate and jettison the canopy, when sat in the aircraft immediately prior to the flight.
> **Safety Recommendation 2009–079**

The Air Officer Commanding No 22 Group responded to this Safety Recommendation on 11 August 2009. In his response he stated that a directive had been made to 1 EFTS Headquarters, on 21 July 2009, that all AEF Flight Commanders were to re-enforce the abandonment procedures outlined in the Tutor Safety Video, and that this requirement would be included in the next change to the Training Group Orders.

The re-enforcement was to include:

- how to release the seat harness,
- how to jettison the canopy,
- how to locate and operate the parachute D-ring,
- how to egress the aircraft.

2.4.4 Standardisation of RAF parachutes

In addition to flying in the Tutor, cadets are also given the opportunity to fly in RAF gliders and motor gliders. Whilst it is standard practice for the cadets to wear parachutes, there are significant differences in the configuration of the D-ring (ripcord handles) on the parachutes used in these different fleets.

A variant of the EB-80 parachute is used with the Viking gliders and Vigilant motor gliders. On this parachute, the D-ring is mounted on the left-hand down strap, facing inwards, and can be operated by either hand pulling the D-ring down and across the body. The EB-85 parachute is used on the Tutor and, whilst the parachute canopy and lines are virtually identical to the EB-80, the harness has been configured to accommodate the RAF life preserver. On this parachute assembly, the D-ring is mounted on the right-hand down strap; however, the D-ring faces outwards and is operated by pulling it outwards and away from the body. It is intended that this action would be done primarily with the right hand, although it can be pulled with either hand.

As cadets have the opportunity to fly these different types of aircraft, there is the potential risk that, given the stress of abandoning an aircraft, they might apply the wrong technique for operating the parachute D-ring. While this was not a factor in this accident, there is the potential for a future human factors related accident. Therefore the following Safety Recommendation is made to the Air Officer Commanding 22 Group:

> It recommended that the Royal Air Force consider standardising the position and operation of the D-ring on parachutes used in Tutor, Viking and Vigilant aircraft.
> **Safety Recommendation 2010-035**

2.4.5 Abandonment of glider

Shortly before the accident, the glider pilot heard and saw the Tutor approaching and, hence, the potential for a collision was apparent. After the collision, he quickly realised that his aircraft was uncontrollable and initiated the actions to abandon the glider. The pilot's experience in instructing, where he repeatedly rehearsed the actions of jettisoning the canopy and deploying the parachute, was beneficial. After the accident, the right side of the canopy frame was found attached to the glider by its hinge pins, indicating that the canopy jettison knob had not been operated, and that he abandoned the glider by using the normal canopy opening knob mounted on the left side of the cockpit.

2.5 Tutor pilot's medical condition

2.5.1 General

The pilot's medical records and post-mortem examination established that the pilot's Ankylosing Spondylitis (AS) was very severe with the majority of the vertebrae in his spine having fused together. This condition would not only have limited his head movement, but he would also have been at greater risk of incapacitation from an impact force. This risk was recognised in 1976 when the RAF decided that he should not undertake parachute training, involving falls onto a mat. Although he was classed as '*unfit ejection seats*', he was not prevented from operating parachute-equipped aircraft.

2.5.2 Pilot's medical history

Individuals with AS are not allowed to join the RAF as pilots. They can, however, remain employed if their AS is diagnosed after they have joined. The Tutor pilot was granted an exemption from the requirement to meet the new applicant standards on the basis that he had held an appropriate medical category until he retired from the RAF shortly before joining the AEF.

The pilot underwent a medical 'renewal' examination at RAF Benson in March 2005 and annual medicals thereafter with the same medical officer (MO). Although his RAF FMed4 was normally kept in the medical centre at RAF Benson, the MO conducting the examination did not refer to it and, therefore, would not have been aware of the pilot's full medical history. Nevertheless, he recognised that the pilot might have difficulties operating the Tutor and, therefore, asked the AEF flight commander to conduct a cockpit check. However, the MO did not appear to appreciate the pilot's increased vulnerability to fracture of the spine. The cockpit check was conducted by the AEF flight commander and recorded as '*satisfactory*' in the pilot's medical records.

It is possible that the pilot's FMed4 may not have been in the RAF Benson medical centre at the time of his examination in March 2005. The investigation was advised that it had been requested by the Command Flight Medical Officer in order to issue a waiver exempting the pilot from a formal medical board on joining the AEF.

2.5.3 RAF Medical records

The RAF medical policy document[3] regarding AS, highlights the limitations of individuals with this condition, with respect to their all-round vision, ability to perform an emergency egress and susceptibility to fracture.

A review of the pilot's medical records would have revealed the entries relating to the restriction on parachute training and the letter suggesting difficulties with vertical look-out. It would also have revealed that over the previous 30 years the pilot had been regularly assessed as fit-to-fly by a number of specialists and that there were entries in his medical records describing the condition as essentially '*burnt out'* (unlikely to deteriorate further). It seems likely, given the information that the condition had 'burnt out', that a review of the FMed4 would not have prevented the MO from declaring the pilot 'fit to fly'. Nevertheless, it would be appropriate for the RAF MO conducting

3 AP 1269A.

the medical examination to review the FMed4, where it exists, when pilots initially join the AEF. The following Safety Recommendation is, therefore, made to the Air Officer Commanding No 22 Group:

> It is recommended that the Royal Air Force ensure that the medical history of pilots is reviewed when they initially apply to join an Air Experience Flight.
> **Safety Recommendation 2010-036**

2.5.4 Look-out

The pilot's ability to conduct an effective look-out was assessed during the cockpit check, instructors' course and as part of his routine proficiency checks.

Cockpit check

The cockpit check was carried out by the then AEF flight commander who informed the MO in a letter that the pilot could reach all the controls and he had no concerns about the pilot's ability to look out. In the letter he wrote that the pilot could see by moving his head and eyes and was able to see above the aircraft and to the rear to the outer tips of the tailplane.

Instructors' course

During the pilot's 'competent to instruct' course with 115 Sqn, a number of his instructors had concerns about his ability to look out in accordance with the approved technique. Consequently, the squadron commander considered it necessary to make the following comment in his RAF F5000:

> *'…he has to work hard to complete a comprehensive lookout scan; an aspect that he actively tries to overcome and achieve.'*

Routine proficiency checks

The pilot's F5000 shows that since he joined the AEF, he had undergone a Tutor conversion course, three currency checks and six Flying Ability Tests (FAT); the last was flown in December 2008. The pilot's log book contained an entry that his last FAT had been carried out in May 2009. There were no comments made in the records for any of these activities regarding the pilot's look-out, other than the currency check flown with the AEF flight commander in March 2006, who commented that:

'look out needs to be improved.'

The evidence regarding the pilot's ability to look out is contradictory. He had passed the required medical examination and cockpit check and, apart from one occasion in March 2006, his previous and current flight commanders had not expressed any concerns. However, concerns had been raised during his course at 115 Sqn.

From the medical evidence it is apparent that the Tutor pilot would have had limited lateral movement of his head and virtually no vertical movement. This, combined with his need to wear corrective lenses, was likely to have significantly compromised his ability to conduct a comprehensive look-out. For the Tutor pilot to have carried out an effective look-out, he would have needed to rotate the upper part of his body; however, if properly secured, the seat harness would have restricted this movement. Whilst he might have been able to look out in the lateral direction, it is considered unlikely that he could have conducted an effective vertical scan.

In summary, it is probable that the pilot's ability to conduct a look-out to RAF standards was compromised by his medical condition. For single pilot public transport operations, the CAA would require a cockpit check to be conducted by a CAAFU examiner, thus ensuring that the checks are independent and carried out to a consistent standard. The following Safety Recommendation is therefore made to the Air Officer Commanding 22 Group:

It is recommended that the Royal Air Force review their policy concerning cockpit checks undertaken to support medical assessments.
Safety Recommendation 2010-065

2.5.5 Medical limitations

The entry referring to a restriction on parachute training was only recorded in the pilot's Fmed4. This would not have been available to non-medical personnel and was only a ground training restriction that did not prevent the pilot from flying parachute-equipped aircraft. AEF pilots are not required to conduct parachute drills involving falls. Therefore there was nothing to alert the AEF to the fact that the Tutor pilot had this restriction, which might have caused them to question his suitability for flying cadets. It is possible that other AEF pilots might also be flying with significant medical limitations of which their management might be unaware. The F5000 includes a section for recording medical limitations. Whilst the Tutor pilot's F5000 had a limitation for '*no ejection seat',* it did not record the limitation for 'no parachute drills'.

Therefore, in order to bring significant medical limitations to the attention of the flying supervisors, the following Safety Recommendation is made to the Air Officer Commanding 22 Group:

> It is recommended that the Royal Air Force ensures that medical limitations relating to Air Experience Flight pilots are recorded in their F5000 (record of flying training).
> **Safety Recommendation 2010-037**

2.5.6 Risk of incapacitation

For patients with AS there is a clear increase in the risk of spontaneous and/or traumatic fractures of the spine as compared to the average population. However, the baseline risk of spontaneous fracture is very low and thus remains low even for an individual with AS.

There are a number of factors specific to aviation, including turbulence and hard landings, which would increase the likelihood of an individual with advanced AS sustaining a spinal injury whilst flying. A review of the pilot's medical records undertaken by a specialist after the accident, established that his condition was severe and thus he was likely to be at greater than average risk of injury or incapacitation.

A review conducted by the UK CAA, following this accident, shows that although elevated, the risk of spontaneous fracture remains within acceptable limits for all types of civil flying. The risk of traumatic fracture is considered acceptable for private and multi-pilot public transport operations. For single pilot public transport operations the risk was considered borderline in those with a long disease history. AEF flying could be considered to be equivalent to single pilot public transport flying and as such it would be appropriate for similar medical standards to be applied.

The following Safety Recommendation is made to the Air Officer Commanding 22 Group:

> It is recommended that the Royal Air Force review their policy on pilots flying with Ankylosing Spondylitis.
> **Safety Recommendation 2010-038**

2.5.7 Retention of records

The records for the pilot's instructional technique course at 115 Sqn in 2008 were disposed of before the accident so it was not possible to review any comments regarding his ability to maintain an effective look-out. While it is standard practice for 115 Sqn to retain these records for regular RAF pilots, the records for VR(T) pilots are destroyed following the production of the pilot's F5000. This is because 115 Sqn are not required to conduct any standardisation flights with VR(T) pilots, which instead are carried out by the pilot's parent unit. If the Commanding Officer of the Tutor pilot's UAS had access to these records, then he might have been aware of the concerns of some of the instructors on 115 Sqn. The following Safety Recommendation is made to the Air Officer Commanding 22 Group:

> It is recommended that the Royal Air Force review their policy for the retention of the complete flying training records of Volunteer Reserve pilots, so that they are available to their supervising officers.
> **Safety Recommendation 2010-039**

2.6 Airspace constraints

2.6.1 AEF Operations

In order for 6 AEF to have achieved their task of flying 6,000 to 8,000 cadets a year, the average flight duration was limited to 20 to 25 minutes. Consequently, most flights were conducted within 10 to 15 miles of the airfield, but because of the proximity of controlled airspace, it was normally only practical to operate to the west and north-west of RAF Benson. Therefore flying took place in a relatively narrow region of uncontrolled airspace oriented approximately NE/SW, eight nm wide and constrained by the RAF Brize Norton CTR, Abingdon airfield and RAF Benson ATZ.

2.6.2 Traffic density

The region of uncontrolled airspace between RAF Brize Norton CTR and RAF Benson ATZ forms a transit route for traffic passing to the west of the London TMA. A number of flying and gliding clubs also operate in this area, which is part of the Oxford Area of Intense Aerial Activity. In the 90 minute period, around the time of the accident, 118 aircraft, of which 85 were gliders, operated in this area. Moreover, within the same time period there were between 15 and 25 aircraft operating within ten miles of RAF Benson ATZ at any one time.

Glider pilots are not likely to fly higher than the cloud-base which, on the day of the accident, was at 4,800 ft agl, nor are they likely to continue en-route flight much below 1,000 ft agl. Thus the actual airspace available for gliding, around the location of the accident site, was approximately 8 nm wide and 4,000 ft high. The aircraft tracks also indicated that pilots generally fly nearer the centre of this corridor, skirting around the east of Abingdon Airfield, which effectively concentrates the traffic into a much smaller volume of airspace than is apparent on the aeronautical charts.

2.6.3 Lower airspace radar service (LARS)

The Tutor pilot could not receive a radar service from RAF Benson as this service was not available during the weekend. However, a LARS was available from RAF Brize Norton and, following the previous Tutor mid-air collision, the AEF had been instructed by HQ 1 EFTS that, where a Traffic Service is available and flight profiles allow, air cadet sorties were to be conducted using a Traffic Service. 6 AEF found that operating with a full Traffic Service was impracticable, as the density of the traffic required constant radio communication. Moreover, the LARS providers are limited by the amount of traffic they can handle. Consequently, a clarifying e-mail was sent by RAF Air Command to the effect that the instruction to obtain a Traffic Service was not mandatory, and that pilots could meet its intent by either requesting a Traffic Service or by monitoring the appropriate radio frequency. However, monitoring the radio only enhances situational awareness when other traffic is using the same frequency. The increased use of the radio would only have reduced the risk of the Tutors from RAF Benson colliding with each other and would not have prevented this accident.

Given the limited capabilities of LARS, and the known difficulties in detecting gliders with primary radar, it is unlikely that on this occasion a LARS service would have prevented the collision.

2.6.4 Flying operations by 6 AEF

Operating aircraft, outside controlled airspace, in airspace with a high traffic density increases the potential for a collision. The probability of a collision involving 6 AEF aircraft might be reduced by operating in areas of lower traffic density. Therefore the following Safety Recommendation is made to the Air Officer Commanding 22 Group:

It is recommended that 1 Elementary Flying Training School review their risk assessment of Air Experience Flight aircraft operating in areas of high traffic density.
Safety Recommendation 2010-040

2.7 Avoiding collisions

There are a number of ways of detecting other aircraft in uncontrolled airspace. The primary method is 'see-and-avoid', where pilots conduct a visual scan to detect other traffic. 'See-and-avoid' can be enhanced by the use of an electronic aid, either air or ground-based, to provide range, bearing and (possibly) height information; such a method is called 'alerted see-and-avoid'. Studies have shown that this method can be eight times more effective than 'see-and-avoid'.

2.7.1 Alerted see-and-avoid

There is no certainty that even if the Tutor pilot had been in receipt of a Traffic Service that he would have been alerted to the presence of the glider. However, had both aircraft been equipped with suitable electronic aids it is possible that the collision might have been avoided.

There are a number of aircraft-based electronic aids currently available, each of which has its limitations. These aids will only provide warnings of other aircraft that are fitted with compatible equipment. Had all the local traffic on the day of the collision been fitted with such electronic aids, this would have resulted in a large number of warnings that would have added to the pilot's workload. There is also a risk that when relying on such electronic aids, a pilot may concentrate on those aircraft that the system has detected to the detriment of looking for other aircraft which do not have the equipment fitted.

The UKAB have previously recommended that the CAA should promote the production, and mandate the use, of a lightweight transponder. In response, the CAA considered Mode S transponders to be the most appropriate equipment, but following extensive consultation with the aviation community decided not to mandate their use in all uncontrolled airspace. The principal arguments against such transponders are their relatively high power consumption, weight and cost. Moreover, if neither conflicting aircraft is in receipt of a radar service, then no alert can be given to the pilots. The cost, weight and power consumption is, to some extent, driven by the range at which the transponder is required to be detected by ground-based radars. These arguments are not as strong for low cost, lightweight collision avoidance systems, such as FLARM, which are not intended to be detected by ground-based radars, but are simply intended to alert pilots to other aircraft within close proximity. For such systems to be effective, it would be necessary for all aircraft operating in uncontrolled airspace to be fitted with compatible equipment.

The AAIB have previously recommended that the CAA should conduct studies into improving the conspicuity of gliders and light aircraft. However, these recommendations were rejected as the CAA did not have regulative authority over gliders and it was felt that it was more practicable to promote good look-out.

In light of the change in regulations and developing technology the following Safety Recommendation is made to the CAA:

It is recommended that the Civil Aviation Authority, in light of changing technology and regulation, review their responses to AAIB Safety Recommendations 2005-006 and 2005-008 relating to the electronic conspicuity of gliders and light aircraft.
Safety Recommendation 2010-041

2.7.2 Probability of collision

The probability of a mid-air collision occurring is a quadratic of the number of aircraft involved, ie as traffic doubles, the risk of a collision quadruples.

The club from which the glider departed was conducting a routine busy summer days flying with 128 gliders launched at a peak rate of 70-80 gliders an hour during the morning. Had a formal gliding competition been taking place, then a NOTAM or AIC would have been issued detailing the likely route and timings, thus alerting other airspace users of the probable concentration of gliders. Indeed, the concentration of gliders involved in this task probably created the level of activity intended to be notified in accordance with AIC Y15/2009 (Notification of Unusual Aerial Activities). However, no formal competition was taking place and each glider was operating autonomously.

Although other UK aviation organisations have pre-planned events for which NOTAMs and AIC action is required, it is generally only gliding clubs which can generate the intense volumes of traffic, seen in the area near this accident, at short notice, on a regular basis. It is not practical for NOTAMs or AIC information to be issued for non-competition gliding activity, particularly as the weather may result in large variations in the number of participants on any particular day.

It is considered that a simple internet based graphical information system would permit the rapid and low-cost dissemination of information that would alert pilots to areas of intense aerial activity. Therefore the following Safety Recommendation is made to the CAA:

> It is recommended that the Civil Aviation Authority liaise with the Sporting Associations and the Ministry of Defence, with a view to developing a web-based tool to alert airspace users to planned activities that may result in an unusually high concentration of air traffic.
> **Safety Recommendation 2010-042**

2.7.3 Warning of intense gliding activity to AEF

On the day of the accident, the ATC at RAF Benson issued two radio warnings of intense gliding activity in the Didcot area. While the pilot of the Tutor involved in the accident was in the aircraft at the time the radio calls were made, it is not known if he received these warnings. Also, the information was not passed to the AEF supervising officer, which might have prompted him to review the flying programme. Therefore the following Safety Recommendation is made to the Commander-in-Chief Air Command:

> It is recommended that the Royal Air Force review the communication procedures between military ATC units and Air Experience Flights to ensure that supervising officers are made aware of significant changes to the local flying environment.
> **Safety Recommendation 2010–043**

3 Conclusions

The Tutor pilot was conducting air experience flights for Air Cadets from RAF Benson and the glider pilot was flying a 300 km task that had been suggested by his gliding club. At the time of the accident both aircraft were operating in an area which was relatively congested due to the good weather conditions on the day and the constraints of the local airspace.

The Tutor pilot was conducting aerobatics and the glider was on a constant track when the mid-air collision occurred and the evidence indicates that the Tutor pilot did not see the glider before he pulled up into a vertical manoeuvre. Whilst the glider pilot became aware of the Tutor, and attempted to take avoiding action, he was unable to prevent the collision.

It is probable that the Tutor pilot's long term medical condition, Ankylosing Spondylitis, restricted the mobility of his head, and therefore affected his ability to conduct a look-out to the RAF standard. His medical condition also resulted in his spinal column becoming fused, making it more vulnerable to fracture from trauma.

There was no evidence that any part of the glider had penetrated the cockpit of the Tutor and the aircraft was assessed as capable of controlled flight following the collision. The apparent lack of recovery of the aircraft, or abandonment action by the pilot, led to the conclusion that he was probably incapacitated during the collision. Following the collision, the Tutor probably entered a spin from which it recovered, before diving steeply to the ground.

Following the collision the cadet released his QRF and moved the canopy operating handle to the open position. Although he had been shown the Tutor passenger safety video, the red 'jettison' handle had not been removed from its housing, which is the first action required to jettison the canopy prior to abandoning the aircraft.

(a) Findings

General

1. The Tutor and glider were serviceable prior to the mid-air collision.

2. The mass and centre of gravity of both aircraft was within the prescribed limits.

3. The Tutor and glider pilots were properly licensed and held the required medical certificates.

4. At the time of the accident the weather was fine with visibility in excess of 25 km.

The mid-air collision

5. The glider pilot was flying at a constant speed and on a constant heading just prior to the collision.

6. The Tutor pilot had completed at least two aerobatic manoeuvres before the collision.

7. The Tutor was on a constant closing bearing with the glider just prior to the collision.

8. The Tutor pilot was flying the aircraft from the right seat.

9. The glider was in the Tutor pilot's field of view, but might have been hidden by the windscreen frame.

10. The glider pilot sighted the Tutor below him and took evasive action in an attempt to avoid the collision.

11. The Tutor pitched up into a vertical manoeuvre and the outer section of the left wing struck the fin and right tailplane of the glider.

12. The tail section of the glider broke away causing the glider to become uncontrollable.

13. The glider pilot opened his canopy and parachuted safely to the ground.

14. The impact of the collision probably fractured the Tutor pilot's spine, leaving him incapacitated.

Post collision

15. The Tutor probably entered a spin immediately after the collision.

16. The Tutor exited the spin in a steep dive, from which it did not recover.

17. The Tutor's longitudinal static stability, although weak, is within the required limits.

18. The damage sustained by the Tutor during the collision would not have prevented it from being recovered from the spin and steep dive.

19. It is unlikely that the cadet would have been able to recover the aircraft from the spin.

20. The Tutor's canopy red 'jettison' handle (locking lever) had not been removed from its housing.

21. Even if he had used the correct procedure, it is unlikely that, in the time available the cadet could have successfully abandoned the aircraft.

22. The impact with the ground was not survivable.

The Tutor pilot

23. The Tutor pilot had Ankylosing Spondylitis, which affected his ability to conduct an effective look-out to the RAF standard.

24. The Tutor pilot had an increased risk of developing a fracture of the cervical spine.

25. An entry, dated 1976 in the Tutor pilot's medical records, stated that he should not undergo parachute training involving falls, due to the risk of fracture to his spine.

26. The Tutor pilot was not restricted from flying aircraft equipped with parachutes.

27. Specialist reports in the Tutor pilot's medical records stated that his Ankylosing Spondylitis was effectively 'burnt out' (not likely to deteriorate further).

28. The Tutor pilot's medical records included a comment that in certain types of aircraft he would have difficulty with vertical look-out.

29. The Tutor pilot's FMed4 folder, containing his medical records, was not reviewed when his medical examination was carried out in 2005.

30. The increased vulnerability for the Tutor pilot's spine to fracture was not identified during the medical examinations undertaken at RAF Benson since joining the AEF in 2005.

31. The Tutor pilot's ability to conduct a look-out to the RAF standard was questioned by instructors at 115 Squadron during his instructional technique course.

32. The Tutor pilot's inability to conduct an effective look-out to RAF standards was not identified during flight and cockpit checks undertaken by the AEF.

The Cadet

33. The accident occurred on the cadet's second flight in a Tutor.

34. The cadet was shown a safety video on the morning of the accident on how to abandon the Tutor.

35. The safety video emphasised that cadets should follow the pilot's instructions, including those relating to the abandonment of the aircraft.

36. Several cadets who were also shown the safety video were unsure as to how to jettison the aircraft's canopy.

37. The cadet released his harness and probably opened the canopy after the aircraft collided.

Airspace and traffic management

38. Air experience flights conducted by 6 AEF normally lasted 25 minutes and routinely included some aerobatic manoeuvres.

39. Flight duration constrained the areas in which the Tutors could operate.

40. The Tutor and the glider were both operating in the Oxford AIAA, in the airspace (gap) between RAF Brize Norton CTR and RAF Benson ATZ.

41. Traffic levels in the 'gap' at the time of the collision were very high.

42. RAF Benson ATC broadcast a message that there was intense gliding activity in the local area during the time the Tutor pilot was in his aircraft.

43. The message from RAF Benson ATC regarding the gliding activity was not passed to the AEF supervising officer.

44. The aircraft were operating outside controlled airspace and neither was in receipt of an air traffic service.

45. There was no onboard traffic alerting system fitted to the Tutor.

46. The FLARM system fitted to the glider was not designed to detect the transmissions from the transponder fitted to the Tutor.

47. Both aircraft were relying on the 'see-and-avoid' principle for collision avoidance in an area of high traffic density.

(b) Causal factors

The following causal factor was identified:

1. Neither pilot saw each other's aircraft in sufficient time to avoid the collision.

(c) Contributory factors

The following contributory factors were identified:

1. The Tutor pilot's medical condition, Ankylosing Spondylitis, limited his ability to conduct an effective look-out.

2. The high density of traffic, in an area of uncontrolled airspace, increased the risk of a collision.

4 Safety Recommendations

The following Safety Recommendation was made on 21 July 2009:

4.1 **Safety Recommendation 2009–079:** It is recommended that 1 Elementary Flying Training School of the Royal Air Force review the passenger safety brief relevant to the Grob GE115E (Tutor) to ensure that passengers are briefed on the circumstances when the harness Quick Release Fitting may be released and the procedure to operate and jettison the canopy, when sat in the aircraft immediately prior to the flight.

The following Safety Recommendations were made in this report

4.2 **Safety Recommendation 2010–032:** It is recommended that the Royal Air Force standardise the terminology used to describe the canopy 'jettison' handle (locking lever) fitted to the Grob 115E (Tutor) in order to avoid confusion and to clarify its function.

4.3 **Safety Recommendation 2010–034:** It is recommended that the European Aviation Safety Agency review the certification of the canopy jettison system on the Grob 115 E, to ensure that it complies with the requirements of CS 23.807 with specific regard to the jettison characteristics up to V_{DO} and simplicity and ease of operation.

4.4 **Safety Recommendation 2010–035:** It recommended that the Royal Air Force consider standardising the position and operation of the D-ring on parachutes used in Tutor, Viking and Vigilant aircraft.

4.5 **Safety Recommendation 2010–036:** It is recommended that the Royal Air Force ensure that the medical history of pilots is reviewed when they initially apply to join an Air Experience Flight.

4.6 **Safety Recommendation 2010–037**: It is recommended that the Royal Air Force ensures that all medical limitations relating to Air Experience Flight pilots are recorded in their F5000 (record of flying training).

4.7 **Safety Recommendation 2010–038:** It is recommended that the Royal Air Force review their policy on pilots flying with Ankylosing Spondylitis.

4.8 **Safety Recommendation 2010–039:** It is recommended that the Royal Air Force review their policy for the retention of the complete flying training records of Volunteer Reserve pilots, so that they are available to their supervising officers.

4.9 **Safety Recommendation 2010–040:** It is recommended that 1 Elementary Flying Training School review their risk assessment for Air Experience Flight aircraft operating in areas of high traffic density.

4.10 **Safety Recommendation 2010-041:** It is recommended that the Civil Aviation Authority, in light of changing technology and regulation, review their responses to AAIB Safety Recommendations 2005-006 and 2005-008 relating to the electronic conspicuity of gliders and light aircraft.

4.11 **Safety Recommendation 2010-042:** It is recommended that the Civil Aviation Authority liaise with the Sporting Associations and the Ministry of Defence, with a view to developing a web-based tool to alert airspace users to planned activities that may result in an unusually high concentration of air traffic.

4.12 **Safety Recommendation 2010–043:** It is recommended that the Royal Air Force review the communication procedures between military Air Traffic Control units and Air Experience Flights to ensure that the supervising officer is made aware of significant changes to the local flying environment.

4.13 **Safety Recommendation 2010–065:** It is recommended that the Royal Air Force review their policy concerning cockpit checks undertaken to support medical assessments.

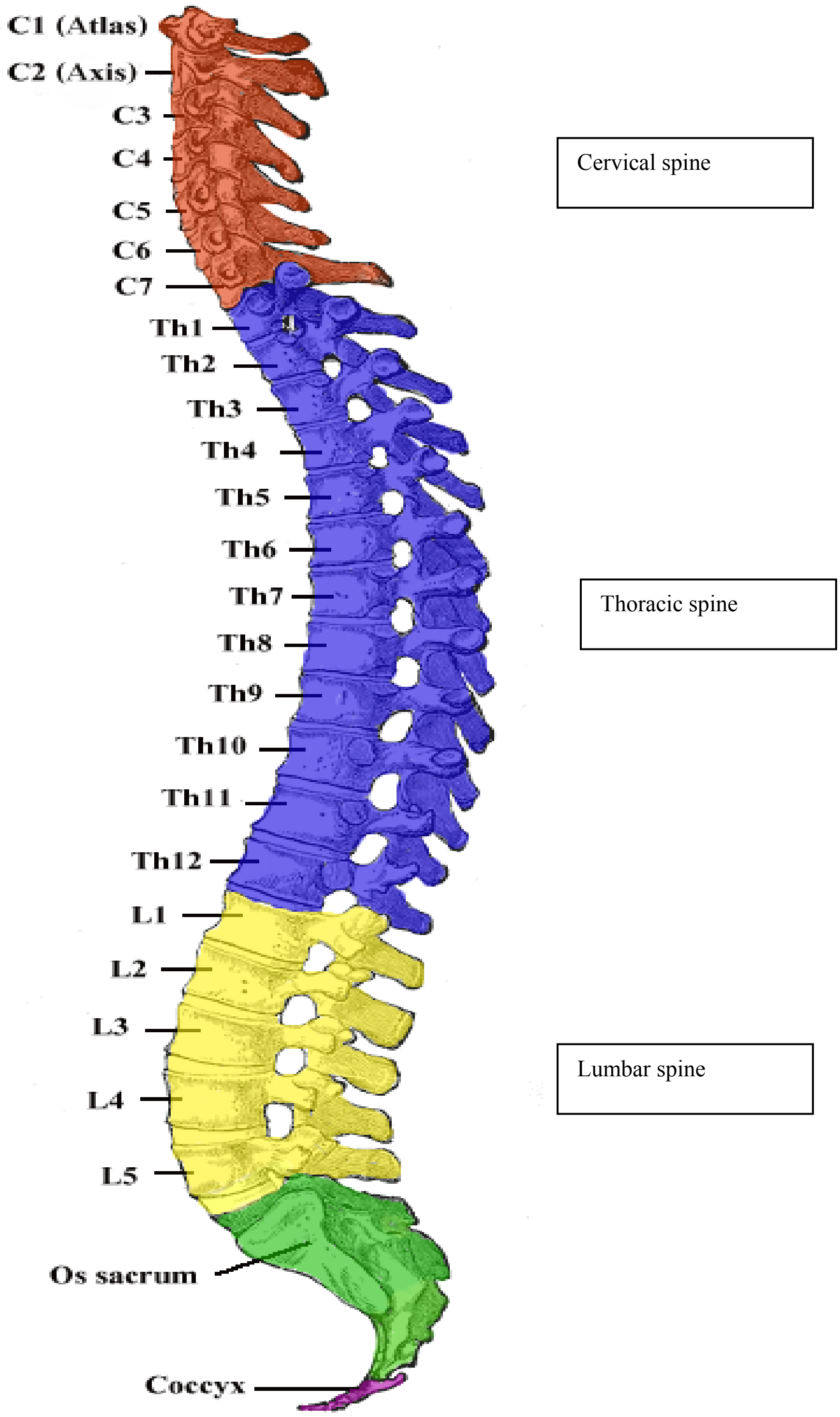
Mr P Claiden
Principal Inspector of Air Accidents
Air Accidents Investigation Branch
Depatment for Transport

Appendix A

Medical terms used in this report

Term	Description
Cervical spine	Seven vertebrae in the spine numbered C1 to C7 from top down.
Kyphotic	Kyphosis is an abnormal outward curving of the spine in the chest area, causing the back to appear even more rounded than usual. This makes the back appear hunched.
Occiput	Back part of the skull.
Ossification	Transformation of cartilage to bone.
Sacro-iliac joints	Joints in the pelvic area joined together by ligaments.
Tragus	The small pointed section of the outer ear.
Iridocyclitis	Inflammation of the eye.
Tragus to Wall	The distance between the Tragus of the ear and the wall is measured when the patient stands with heels and buttocks touching the wall, knees straight, shoulders back, and places the head as far back as possible, keeping the chin in.

Appendix A


C1 (Atlas)
C2 (Axis)
C3
C4
C5
C6
C7
Th1
Th2
Th3
Th4
Th5
Th6
Th7
Th8
Th9
Th10
Th11
Th12
L1
L2
L3
L4
L5
Os sacrum
Coccyx
Cervical spine
Thoracic spine
Lumbar spine

Appendix B

Flight Tests

1. The Civil Aviation Authority undertook a number of flight tests, on behalf of the AAIB to:

- assess the aircraft's longitudinal static stability,
- assess the aircraft's spin characteristics,
- establish if the cadet's loose QRF could have restricted the controls and prevented the aircraft from recovering from the dive.

The flight test was carried out at Royal Air Force (RAF) Cranwell using an identical Grob 115E to the accident aircraft and flown by a CAA test pilot accompanied by a member of the RAF Service Inquiry. The flight lasted one hour and 30 minutes, the takeoff weight was 975 kg and the position of the CG was 0.228 m forward of the datum.

2. Longitudinal static stability

Longitudinal static stability refers to the tendency of an aircraft to return to its trim condition after a nose-up or nose-down disturbance.

In the first group of tests, the aircraft was trimmed for level flight at airspeeds of 80, 90, 100, 110 and 118 kt, with the engine speed set at 2,400 rpm. At each trim speed, the control column was moved rearwards until the airspeed had reduced by approximately 10%; the control column was then released. In each test, the aircraft accelerated back through the trim speed and then slowed, to regain the datum trim speed. Whilst the tests demonstrated that the aircraft possesses static longitudinal stability, it was noted that, at the higher airspeeds, the aircraft was very slow to return to the trimmed position.

In the next group of tests, the aircraft was trimmed, in a shallow dive, for airspeeds of 120, 130, 140 and 150 kt, with the engine set at full power and 2,400 rpm. As in the first tests, the control column was moved rearwards until the airspeed decreased by approximately 10% when it was released. Again the aircraft exhibited static stability although, once more, it was very slow to return to the trimmed position.

Appendix B

The aircraft's natural ability to recover from a dive was assessed by trimming the aircraft at 120 kt with the engine set at full power and 2,400 rpm. The aircraft was then dived, following a wingover, at increasing pitch-down attitudes from 45° to approximately 60° and allowed to accelerate to 120 kt, when the control column was released. In each case, the aircraft accelerated through 120 kt before slowly pitching nose-up. The test was terminated at 60° as the airspeed reached 180 kt, which was 5 kt below the V_{NE} of 185 kt.

In the final test, the aircraft was flown in a gentle loop manoeuvre with the aircraft trimmed at 120 kt for an entry speed of 130 kt. As the aircraft came through the top of the loop, and started to pitch nose-down, the control column was released. The aircraft accelerated rapidly in a near vertical pitch-down attitude. In order to prevent the aircraft exceeding V_{NE}, it was necessary to recover from the dive at 160 kt, by applying a normal acceleration of 5g.

The flight tests demonstrated that the Grob 115E had sufficient positive/stable longitudinal static stability to satisfy the requirements of FAR/CS 23.175b. However, the stability was assessed as weak, particularly at higher speeds, and it was likely that in a near-vertical dive the aircraft would exceed V_{NE}, and lose considerable height, before any natural tendency to pitch nose-up would have a significant effect.

3. Aerobatic characteristics

The Grob G115E flight manual states that the aircraft will loop from entry speeds of between 120 kt and 135 kt. Full throttle should be used and the engine speed should be between 2,400 and 2,700 rpm. The initial pull-up should be at 4 g.

A number of loops were flown at 4,000 ft to 6,000 ft with the engine set at full power and 2,400 rpm. The aircraft was allowed to accelerate to 130 kt in a shallow dive before the control column was moved rearwards and the aircraft pitched up, pulling 2.5 to 3 g. As the aircraft flew upwards through the vertical the airspeed was consistently 80 kt, which reduced to 40 to 50 kt at the top of the loop. The aircraft then accelerated quickly and reached an indicated airspeed of 70 kt to 80 kt by the time it was pointing vertically downwards.

Appendix B

4. Spinning characteristics

The aircraft manufacturer advised the AAIB that typical descent rates in a spin are 10,000 fpm to 14,000 fpm (50 m/s to 70 m/s).

Prior to the start of the spinning tests, the stall characteristics were established with the aircraft in a wings level attitude, with the flaps retracted and the engine at idle power. The aircraft stalled at 56 kt and was preceded by a distinctly audible warning horn and light airframe buffeting. There was no tendency for the aircraft to drop either wing.

The damage to the outer section of the left wing, which occurred during the collision, would make it more likely that the aircraft would enter a spin to the left, so it was decided to concentrate on the left-hand spinning characteristics of the aircraft. Five spins were performed, during which the engine power was set at idle during four of the tests and at full power for the fifth test.

The procedure during these tests was to reduce the engine power to idle in level flight and allow the aircraft to slow to around 60 kt. The control column would then be moved fully rearwards and full rudder applied in the required direction of spin (pro-spin). The ailerons were held in the neutral, full left and full right position as required for each test. Recovery was commenced by reducing the engine power to idle during the first four tests, applying full opposite rudder and then pushing the control column forward until recovery was achieved. The engine power was left at full power during the recovery in the fifth spin. The results of these tests are detailed in Table 1.

The final test simulated the aircraft entering a spin, with maximum engine power and with the control column free, which might have been the situation after the aircraft collided with the glider. The aircraft was trimmed to 120 kt, engine power was set at full throttle and the aircraft was accelerated in a shallow dive to 130 kt. A 3 g pull-up was then initiated and, when the aircraft was fully inverted at the top of the loop, pro-spin controls were applied. As soon as the aircraft entered the spin the controls were released and allowed to float freely. Almost immediately, the aircraft ceased spinning and ended up in a near vertical dive. The airspeed increased rapidly until the test was terminated at 160 kt.

The tests established that the Grob 115E has very benign spin characteristics

Appendix B

Test	Description	Time to recover	Rate of rotation	Height loss
1	Spin to the left for 4 turns. Ailerons neutral.	1 turn	180°/ sec	1,800 ft
2	Spin to the right for 4 turns. Ailerons neutral.	1 turn	120°/ sec	2,000 ft
3	Spin to the left for 3 turns. Full left aileron applied.	1 turn	270°/ sec	2,000 ft
4	Spin to the left for 3 turns. Full right aileron applied.	1 turn	180°/ sec	2,000 ft
5	Spin to the left for 2 turns. Ailerons neutral. Full power applied.	1 turn	120°/ sec	Reluctant to spin

Table 1

Summary of spinning tests.

and recovers easily, as soon as pro-spin controls are released, or spin recovery action is taken. If a spin was entered at the top of a loop it is likely that the aircraft would recover naturally, as long as pro-spin controls are not applied and maintained.

5. Previous spinning occurrence

A Defence Flight Safety occurrence report was raised following an incident on 14 August 2009, when an instructor on a training flight experienced difficulties in recovering a Tutor from a spin.

The instructor was conducting a spin training exercise with a UAS student and entered the spin at 6,500 ft. The instructor reported that upon entry to the spin, the student's application of full rudder and elevator was not positive enough and while the aircraft settled into a spin, the rate of rotation appeared much greater and the pitch attitude much flatter than normal. The instructor took control and commenced the normal spin recovery drill, but with full opposite rudder applied and the control column fully forward, there was no sign of recovery. The instructor, therefore, re-applied full pro-spin control, with the ailerons in the neutral position, before recommencing the spin recover procedure. As the aircraft passed 3,500 ft the instructor instructed the student to prepare to abandon the aircraft. However, just as he prepared to jettison the canopy, the aircraft recovered from the spin.

This occurrence illustrates that, whilst the CAA flight tests demonstrated that the Tutor normally recovers quickly and easily from a spin, there are situations when the aircraft will take longer to recover and will lose considerably more height than would normally be expected.

6. Control restriction

A test was carried out to establish if the cadet's crotch strap and QRF could have become jammed behind the control column and restricted its rearwards movement sufficiently to prevent the aircraft recovering from the dive. Prior to the start of the flight, the left seat QRF was placed behind the control column, which was then pulled rearwards as far as possible. The position of the control column relative to the bottom of the instrument panel was established by the use of a retractable tape measure secured to the instrument panel.

During this test, the aircraft was dived to a speed of 120 kt with the engine set at maximum power and 2,400 rpm. The control column was then moved to the fully aft 'restricted' position determined prior to the start of the flight. On each occasion the aircraft pitched nose-up, achieving an acceleration of +3 g. The test concluded that with an airspeed of 120 kt, or above, a control restriction from a jammed QRF would have had negligible effect on the aircraft's ability to pull out of a diving manoeuvre.

Appendix C

UK uncontrolled airspace and ATC services, LARS and AIAA

1. Class G (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. Regardless of the ATC service being provided, pilots are ultimately responsible for collision avoidance and terrain clearance.

2 Air Traffic Services Outside Controlled Airspace (ATSOCAS)

Lower Airspace Radar Service can provide four levels of service: Basic Service, Traffic Service, Deconfliction Service and Procedural Service.

A Basic Service is intended to offer the pilot maximum autonomy, the controller/ information service officer will pass information pertinent to the safe and efficient conduct of the flight. This can include general activity information within a unit's area of responsibility.

A Traffic Service is where the controller provides the pilot with surveillance-derived traffic information on conflicting aircraft. No deconfliction advice is passed and the pilot is responsible for collision avoidance.

A Deconfliction Service provides the pilot with traffic information and deconfliction advice (headings/levels) on conflicting aircraft. However, the avoidance of other aircraft is ultimately the pilot's responsibility.

A Procedural Service is not relevant in this case.

3. Lower Airspace Radar Service (LARS)

A LARS service is provided only by notified Air Traffic Service (ATS) units, to aircraft operating below Flight Level 95 within defined times and geographical areas. ATSOCAS are the set of services that may be provided in Class G airspace, either as a part of LARS provision, or otherwise to aircraft in communication with a non-LARS unit.

Appendix C

4. Areas of Intense Aerial Activity (AIAA)

Areas of Intense Aerial Activity (AIAA) are areas situated in Class G airspace below FL195 and have been denoted in UK military and civilian Aeronautical Information Publications (AIPs) and act as a signpost on aeronautical charts. These areas have no formal reserved status and afford the aircraft operating within the published area no additional protection. These areas are listed as airspace within which the intensity, type of activity and potential interaction of civil and/or military flying is exceptionally high or where aircraft, either signally or in combination with others, regularly participate in unusual manoeuvres.