AIRCRAFT ACCIDENT REPORT 2/92

Air Accidents Investigation Branch

Department of Transport

Report on the accident involving Royal Air Force Jaguar T2A, XX843 and Cessna 152, G-BMHI at Carno, Powys, Wales, on 29 August 1991

This investigation was carried out in accordance with
The Air Navigation (Investigation of Air Accidents involving Civil and Military Aircraft or Installations) Regulations 1986

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Department of Transport
Air Accidents Investigation Branch
Royal Aerospace Establishment
Farnborough
Hants GU14 6TD

29 April 1992

The Right Honourable John MacGregor
Secretary of State for Transport

Sir,

I have the honour to submit the report by Mr R StJ Whidborne, an Inspector of Air Accidents, on the circumstances of the mid air collision between RAF Jaguar T2A, XX843 and Cessna 152, G-BMHI that occurred at Carno, Powys, Wales, on 29 August 1991.

I have the honour to be
Sir
Your obedient servant

K P R Smart
Chief Inspector of Air Accidents

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GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AAIB	-	Air Accidents Investigation Branch
AAR	-	Aircraft Accident Report
agl	-	above ground level
amsl	-	above mean sea level
ALFENS	-	Automated Low Flying Enquiry and Notification System
ANO	-	Air Navigation Order
AOC	-	Air Operator's Certificate
ATC	-	Air Traffic Control
ATS	-	Air Traffic Services
℃	-	Centigrade (Celsius)
CAA	-	Civil Aviation Authority
CANP	-	Low Level Civil Aircraft Notification Procedure
ETAs	-	estimated time(s) of arrival
FIR	-	Flight Information Region
GASILs	-	General Aviation Safety Information Leaflets
HISLs	-	High Intensity Strobe Lights
HUD	-	Head-Up-Display
IAM	-	Institute of Aviation Medicine
ICAO	-	International Civil Aviation Organisation
JAS	-	Joint Airmiss Section
JAWG	-	Joint Airmiss Working Group
kg	-	kilogram(s)
LFA	-	Low Flying Area(s)
mb	-	millibar(s)
msd	-	minimum separation distance
nm	-	nautical miles
MHz	-	megahertz
NATS	-	National Air Traffic Services
NOTAMS	-	Notices to Airmen
RAC	-	Rules of the Air and Air Traffic Services
radalt	-	radar altimeter
RAF	-	Royal Air Force
TBC	-	Tactical Booking Centre
UHF	-	Ultra High Frequency
UK	-	United Kingdom
UK AIP	-	United Kingdom Air Pilot
USAF	-	Unites States Air Force
UTC	-	Coordinated Universal Time

Air Accidents Investigation Branch

Aircraft Accident Report No. 2/92

(EW/E91/8/1)

Aircraft: 1	
Registered owner:	Skyviews and General Limited
Operator:	Robert Mark Cooper
Type:	Reims Cessna
Model:	F152
Registration:	G-BMHI
Aircraft: 2	
Owner and operator:	Royal Air Force (RAF)
Type:	Sepecat Jaguar
Model:	T2A
Registration:	XX 843
Place of accident:	Carno, Powys, Wales
Date and Time:	29 August 1991 at 1254 hrs

All times in this report are UTC

Synopsis

The accident was notified to the Air Accidents Investigation Branch (AAIB) at 1343 hrs on 29 August 1991 and an investigation began the same day. The AAIB team consisted of Mr R StJ Whidborne (Investigator in Charge), Mr A W Skinner (Operations) and Mr C I Coghill (Engineering). An RAF Board of Inquiry was also convened under Service Regulations.

The Jaguar T2A[1], based at RAF Coltishall, near Norwich was on a routine low level training flight. The Cessna F152[2], which was temporarily based at Halfpenny Green aerodrome, near Bridgnorth was engaged on an aerial photography flight. Prior to the accident the Cessna had been circling at low level close to and over the village of Carno for more than one hour. There is evidence that, during this time, the pilot had been taking photographs of properties in the

[1] Referred to throughout this report as the Jaguar.
[2] Referred to throughout this report as the Cessna.

local area. He was using a trigger operated hand-held camera and photographing through the open left side cabin window. Immediately prior to the accident, the Jaguar was flying south east alongside the A470 road in the valley from Machynlleth to Newtown, Powys, mid Wales. The aircraft was flying at a height between 300 and 400 feet above ground level (agl) and at a ground speed of 450 knots. At this time eyewitness evidence indicates that the Cessna had just rolled out of a left hand turn and was flying straight and level on an easterly heading towards the centre of Carno.

At 1254 hrs the two aircraft collided over open ground approximately 100 metres to the west of Carno. The Cessna pilot was killed instantly and his aircraft destroyed. The direction of impact with the Cessna was on its left side and from the rear quarter. On impact the entire Jaguar wing detached from its fuselage mounting points. The fuselage continued for approximately 1500 metres rolling rapidly to the right. Almost immediately after the collision, the rear seat pilot initiated ejection which was successful and he escaped although suffering serious injuries. The front seat pilot initiated ejection about three quarters of a second later and the automatic sequence functioned correctly. However, the ejection was outside the escape envelope, the pilot failed to separate fully from the seat and was killed on impact with the ground.

The report identifies the following causal factors:

a. The crew of the Jaguar and the pilot of the Cessna did not see each other's aircraft in time to take avoiding action.

b. Both aircraft were flying at a height which was less than 500 feet agl.

c. The Cessna pilot had not notified the flight in accordance with Low Level Civil Aircraft Notification Procedure (CANP)

Five safety recommendations have been made.

1 Factual Information

1.1 History of the flights

The Cessna had been based at Halfpenny Green since 25 March 1991 for the purpose of carrying out aerial surveys and air photography flights. Private properties were photographed from the air and subsequently the owners of the properties or any other interested parties were invited to purchase the prints. Between 25 March and 29 August 1991 the aircraft had carried out 75 flights from Halfpenny Green, of which 53 were on weekdays and 22 on weekends. The aircraft was fitted with long range fuel tanks and the solo pilot normally flew the aircraft carrying a trigger operated, hand-held camera which he used to take photographs through the open left side cabin window.

At about 1000 hrs on 29 August 1991 the pilot arrived at Halfpenny Green to prepare for a further air photography flight. He did not visit the Control Tower or file a flight plan and there is no evidence that he obtained a weather forecast. He taxied the aircraft to the refuelling bay where he requested that it be refuelled to full tanks and 96 litres were loaded. At about 1035 hrs the pilot restarted the engine and contacted the Flight Information Service Officer on the Very High Frequency 121.95 MHz and advised an aerial survey flight with one person on board and six hours endurance. He did not take the opportunity report his intended route or his expected return time. The endurance figure is in accordance with the aircraft manufacturer's performance data.

The aircraft took off from Halfpenny Green at 1044 hrs and was observed to climb away towards the west. After about 10 minutes the pilot reported that he was changing to Welshpool Air Traffic Control (ATC) on 123.25 MHz. There is no record that he called Welshpool and there is no evidence of any further radio messages received from the aircraft by any other ATC authority.

It was not possible to determine precisely the aircraft's track after departing Halfpenny Green until its arrival over Carno, which is a direct track distance of 46 nautical miles. At normal cruising speed in the prevailing wind conditions this should have taken about 28 minutes. However from about 1130 hrs eyewitnesses at Carno reported first noticing the aircraft flying a succession of low level left hand orbits of the areas immediately surrounding the village. Many of the eyewitnesses commented on how low the aircraft was flying and that they were able to see clearly the words 'AIR SURVEY' painted on the under side of the right wing. Evidence retrieved from the wreckage showed that the pilot had been taking aerial photographs at various stages during the flight.

The two pilots of the Jaguar attended the morning weather briefing at RAF Coltishall and thereafter commenced planning a low level training flight through Wales. The nominated Captain of the aircraft was to occupy the rear seat and the second pilot was to fly the aircraft from the front seat. The flight was their first of the day and was planned as a medium level 'Lichfield Corridor' transit, letting down near Ludlow to fly low level not below 250 feet Minimum Separation Distance (msd) through Wales to a target to the south of Machynlleth. Post target the plan was to route low level north towards Machynlleth and then south east around the Tactical Training Area LFA 7T which was active, before returning to Coltishall at medium level via the Lichfield Corridor. After a check of the Notices to Airmen (NOTAMS) and other restrictions the briefing was completed by the duty authorising officer. There were no warnings of civil aircraft operations in the vicinity of Carno.

Before take off, the Jaguar's canopies were checked and found to be clean and without blemishes. The aircraft took off from RAF Coltishall at 1202 hrs and shortly afterwards its High Intensity Strobe Lights (HISLs) were switched ON and selected to WHITE. The radar altimeter (radalt) audio warning was selected to activate at 250 feet. The flight thereafter proceeded uneventfully until the recovery phase. About 20 seconds prior to the collision the Jaguar was passing Talerdigg and rolled out onto a southeasterly heading along the A470 valley with the road between 500 and 1000 metres to its left (see Appendix A). The sun was in its 2 to 3 o'clock position, high and visibility was in excess of 10 kilometres. The front seat pilot was flying the aircraft at a height between 300 and 400 feet measured by the radalt at a speed of about 450 knots. The Head-Up-Display (HUD) was ON and selected to BRIGHT. The rear seat pilot was concentrating his look out in the forward hemisphere and did not see any other aircraft at this stage of the flight. Very shortly after entering the valley, the rear seat pilot recalls directing the other pilot's attention towards a red telephone box which was situated alongside the A470 road and the aircraft was momentarily banked slightly to the left in order to get a better view of it.

At the same time that the Jaguar entered the A470 valley eyewitness evidence indicates that the Cessna was rolling out of a left turn before flying straight and level on an easterly heading towards the centre of Carno. At 1254 hrs the Jaguar struck the Cessna on its left side from the rear quarter. The Cessna immediately disintegrated whilst the Jaguar continued on its heading, shedding its wings and other parts of its structure before striking the ground some 1500 metres further on. The Cessna pilot was killed instantly and the aircraft destroyed. The Jaguar fuselage continued on approximately the impact heading whilst rolling rapidly to the right. Almost immediately after the collision the rear seat pilot initiated ejection which was successful. The front seat pilot is believed to have initiated ejection approximately three-quarters of a second later and the automatic sequence

functioned correctly. However, the ejection parameters were outside the escape envelope and the pilot, having failed to separate from the seat, received fatal injuries upon impact with the ground.

The Jaguar rear seat pilot has no recollection of the collision and he remembers nothing from the time that the telephone box was sighted until hearing a female voice as he lay injured on the ground. The collision occurred at a position where, under normal conditions, the Jaguar would have needed to start a full left turn in order to negotiate the terrain ahead safely.

1.2 Injuries to persons

	Crew	Passengers	Others
a. Cessna			
Fatal	1	-	-
Serious	-	-	-
Minor/None	-	-	
b. Jaguar			
Fatal	1	-	-
Serious	1	-	-
Minor/None	-	-	

1.3 Damage to aircraft

Both aircraft were destroyed.

1.4 Other damage

A farm house, Trawsgoed-pellaf, and its outbuildings were severely damaged by falling debris and its garden was devastated. Four private houses in Carno sustained roof damage and debris was widely scattered over private gardens and farm land. 1500 metres further on the Jaguar fuselage section struck the ground where it exploded, causing a wide-spread ground fire. The silage crops from two fields were destroyed. The ground fire spread rapidly resulting in the destruction of six standing trees and approximately 150 metres of timber stock proof fencing. Arable fields were also contaminated by unburned fuel. Twelve sheep and two farm cats were killed as a result of both the impact and the subsequent fire. Minor damage also occurred to some gate posts and fencing during the wreckage recovery operation.

1.5 Personnel information

1.5.1 *Cessna:*

Pilot:	Male, aged 46 years
Licence:	Private Pilot's Licence Groups A & B IMC & Night Ratings (both expired)
Medical Certificate:	A Class 3 Medical Certificate with no limitations issued on 18 May 1991 and valid until 17 May 1993
Certificate of Experience:	Re-issued on 23 May 1991 and valid until 22 June 1992
Total flying hours:	2045 hours
Total hours on type:	1654 hours on Cessna single engine variants

1.5.2 *Jaguar:*

1.5.2.1 *Captain (rear seat):*	Male, aged 40 years. RAF pilot
Medical examination:	24 June 1991
Instrument flight check:	14 September 1990
Competency check:	7 August 1991
Total pilot hours:	3825 hours
Total hours on type:	2868 hours
Total hours last 30 days:	30 hours
1.5.2.2 *Second pilot (front seat):*	Male, aged 40 years. RAF pilot
Medical examination:	29 August 1991
Instrument flight check:	Not applicable
Competency check:	Not applicable
Total pilot hours:	3618 hours
Total hours on type:	917 hours
Total hours last 30 days:	6 hours

1.6 Aircraft information

1.6.1 Cessna

The Cessna was a high wing single engined monoplane with strutted wings having a span of 33 feet. The two place cabin had side by side seating. Its operating speed in the accident situation was assumed to have been between 65 and 90 knots.

Type:	Reims Cessna F152
Constructor's Number:	F152-1607
Date of Manufacture:	1979
Certificate of Registration:	Skyviews and General Limited
Certificate of Airworthiness:	Transport Category (Passenger) Expiry date: 14 March 1992
Certificate of Release to Service:	6 August 1991 at 5532.25 hours
Total airframe hours (at accident):	5584.25 hours
Maximum total weight authorised:	758 kg
Estimated weight at time of accident:	702 kg
Centre of Gravity at time of accident:	Within approved limits
Conspicuity:	The aircraft's predominant colour was white, with a red stripe along each side of the fuselage. The words AIR SURVEY were painted in black letters 19 inches high on the under side of the right wing A red anti-collision light was mounted on top of the fin

Maintenance history:

Date	Airframe hours	Check	Remarks
21 July 1991	5485.15 hours	50 hour	4 hours 20 minutes past certified 10% extension
6 August 1991	5532.25 hours	150 hour	Calculated from journey log

The aircraft's Log Book showed that up to 21 July 1991 it had been maintained to the Approved Maintenance Schedule No CAA/LAMS/FW/1978 as required by the Certificate of Airworthiness. Worksheets showed a further check (150 hour) having been completed on 6 August 1991.

Since the engineer who had completed the 150 hour check did not have the Log Books available he did not issue a 'Release to Service' Certificate for the Log Book. The worksheets themselves, however, were stamped with a Certificate of Release to Service. The Journey Log showed that, at the time of the accident, the aircraft had completed another 52 hours flying but there was no record found of any further maintenance having been carried out.

1.6.2 *Jaguar*

The Jaguar aircraft was a two seat advanced trainer version of the twin engined fighter bomber with two crew members seated in tandem, each cockpit having full flying instruments and controls. The aircraft was 57 feet long and had a wingspan of just over 28 feet. Two aerodynamically shaped underwing drop fuel tanks of 924 kg capacity were mounted on each inboard wing pylon and the aircraft also carried four smoke and flash practice bombs weighing 3 kg each. The Jaguar T2A was not normally fitted with an airborne radar that would enable pilots to detect the presence of other aircraft in flight.

Type:	Sepecat Jaguar T2A
Service Number:	XX 843
Date of Manufacture:	July 1975
Total Airframe hours:	4057 hours
Last maintenance:	At 3977 hours
Next maintenance due:	At 4102 hours
Maximum take off weight:	15,000 kg
Estimated weight at time of accident:	10,500 kg
Centre of Gravity at time of accident:	Within approved limits
Conspicuity:	Military camouflage, predominantly dark green with HISLs on top and bottom centres of the fuselage

The aircraft had been maintained in accordance with RAF requirements. Deferred defects included temporary cable repairs to a T6 junction box and the rear cockpit Projected Map Display. A crack in the knuckle joint of the right hand landing gear was programmed for repair at the next major servicing.

1.7 Meteorological information

1.7.1 Forecast

The pilots of the Jaguar attended the RAF Coltishall weather briefing at 0730 hrs on 29 August 1991. The low level forecast for the period 1200 hrs to 1700 hrs covering Mid Wales was:

Visibility:	15 to 25 kilometres, occasionally 8 kilometres.
Cloud:	Broken cumulus and stratocumulus cloud, base between 2000 and 4000 feet and scattered stratocumulus base 1200 to 1800 feet over the sea and coasts.
Surface wind:	Easterly at 7 knots.
Temperature:	+21°C.

In addition to the formal briefing, the Jaguar second pilot requested an update on the weather conditions from the duty forecaster at 1012 hrs. He was informed that surface visibility was generally 15 kilometres over South Wales improving to 20 kilometres by 1200 hrs and that over West Wales the visibility was currently 5000 metres to 7 kilometres. Surface weather reports of the actual conditions at Cardiff Airport, Swansea, Brawdy and Aberporth, timed at 0950 hrs were also quoted. These actual reports all confirmed the general forecast weather situation.

1.7.2 Aftercast

An aftercast was prepared by the Meteorological Office, Bracknell for the area of the accident site at 1300 hrs on 29 August 1991. A ridge of high pressure extended westwards across England and Wales and was centred over the southern North Sea with a pressure of some 1031 mb.

Visibility:	8 to 10 kilometres
Weather:	Nil
Cloud:	Nil or small amounts of stratocumulus base 3000 feet
Surface Wind:	Variable mainly easterly at 5 knots
Temperature:	+ 23°C

An RAF pilot, who was flying within 20 kilometres of the accident site at the time of the accident, has reported that the visibility was good 'down sun' and was in excess of 10 kilometres. There was no significant low cloud and the sun was shining. Along the final collision course the sun would have been at an elevation of 45° and 40° right of the Jaguar's sight-line to the Cessna.

1.8 Aids to navigation

Not applicable.

1.9 Communications

The Jaguar crew maintained routine radio contact with Military Air Traffic Control Units where possible throughout the flight. The reason the Cessna pilot did not carry out his stated intention to contact Welshpool or any other ATC authority is not known.

1.10 Aerodrome information

Not applicable.

1.11 Flight recorders

Neither aircraft was fitted with any type of flight recorder, nor were they required to be fitted under existing regulations.

1.12 Wreckage and impact information

The engineering investigation was concerned primarily with determining the impact angles of the two aircraft and the nature of the damage suffered in the collision. This was achieved by studying the disposition of the wreckage on the ground (see Appendix B) and by a partial reconstruction of the two aircraft after the wreckage had been recovered from the accident site.

Aircraft wreckage was spread over a large area, covering a total distance of about two kilometres in a south easterly direction from Carno village. From the evidence of the wreckage itself it was apparent that the collision had occurred above a field immediately to the west of Carno. The field contained much light wreckage which decelerated rapidly after the collision and fell almost vertically to the ground. The light wind had carried some paper and insulation material north west from the collision point.

The wreckage found close to Carno village comprised all of the Cessna, which had disintegrated, together with fragments of those parts of the Jaguar which had collided with the Cessna. Fragments were found from the Jaguar's left wing, left underwing tank and its left tailplane. The complete remaining wing of the Jaguar, comprising both left and right wings as one structure, was found towards the south eastern end of the wreckage trail at Carno. Between 800 and 1200 metres downtrack from the collision point there was debris associated with the ejection of the crew from the Jaguar and the complete fuselage of the Jaguar which had hit

the ground at the farm, Trawsgoed-pellaf, about one and a half kilometres from the collision. On impact the fuselage had disintegrated and the fuel which it had contained had ignited. The wreckage and fireball had caused severe damage to the precincts of the farm and to the farm buildings themselves over a distance of about 300 metres.

It was determined that the Jaguar collided with the Cessna from the Cessna's left rear quarter (see Appendix C). At the moment of impact the Jaguar was banked to the left by about 35° and the Cessna was pitched slightly nose up in a climbing attitude. This nose up attitude could have caused the approach of the Jaguar to be further obscured by the aft edge of the cabin roof and the trailing edge of the left wing. The left wing of the Jaguar with its underwing tank destroyed the Cessna's cabin. A bulkhead from the tank was found heavily contaminated with human remains. The Jaguar's left taileron and left ventral strake made diagonal cuts in the Cessna's right wing which severed it in two places. The Jaguar's wing also collided with the Cessna's engine and it was the effect of this impact which caused the detachment of the Jaguar's wing from the fuselage. The impact of the Cessna's engine on the Jaguar's wing was from the front and from slightly below reflecting the effect of the Jaguar's bank angle, its normal flying angle of incidence and the relative velocities of the two aircraft. Amongst other effects, this would have imparted to the Jaguar a rolling motion to the right. The fractures in the wing attachment points showed evidence of the wing moving aft and rolling to the right as it detached. The rolling motion imparted to the separated fuselage would have made the escape of the crew, through use of their ejection seats, more problematical. The operation of the Jaguar's ejection system was investigated by RAF specialists.

The main part of the Cessna's fuselage, comprising the cabin floor and seats, the main landing gear and the rear fuselage with the tailplane and fin attached were found alongside the Afon Cerniog stream about 200 metres south east of the collision. A large amount of photographic equipment including films, a camera body, a lens and a combined motor wind and trigger unit were found close to the cabin. The camera body had a blank cover fitted instead of a lens and had obviously not been in use but fragments of another identical camera body mounted on another motor rewind and trigger unit were found in the field under the collision point.

1.13 Medical and pathological information

The second pilot of the Jaguar had received a heart and lung transplant in September 1990. The operation had been successful and the pilot was prescribed immunosuppressive medication on a life-long basis to guard against the possibility of organ rejection. He subsequently passed a comprehensive medical

examination and was cleared to fly in RAF aircraft only under the supervision of a qualified pilot. A further requirement was that he had a full medical examination prior to each flight. The required medical examination was carried out immediately before the accident flight and he was assessed as fit to fly.

An autopsy and toxicological examination was carried out on the pilot of the Cessna and the second pilot of the Jaguar. No evidence was found of medical factors which might have caused or contributed to the accident.

The captain of the Jaguar had a full medical examination before being returned to flying duties.

1.14 Fire

Almost immediately after the collision and separation of the Jaguar's wings its fuselage section developed a fierce fire. The subsequent ground impact disrupted the Jaguar's internal fuel tanks and the fire quickly spread. The Powys Fire Service was alerted at 1257 hrs by an emergency call and five appliances, manned by 24 Fire Officers arrived at the scene at 1342 hrs. At 1515 hrs the fire was considered to be under control and the last appliance left the site at 1942 hrs.

1.15 Survival aspects

The accident to the Cessna was non-survivable.

The Jaguar rear seat pilot initiated his ejection some 2 to 3 seconds after the collision. The rear canopy jettison system functioned correctly and he exited the aircraft when the fuselage was in a favourable attitude. The system functioned correctly and he landed in a field some 1000 metres from the point of collision and to the right of the fuselage track. Shortly after leaving the aircraft the pilot's flying helmet came off.

The Jaguar front seat pilot initiated his ejection sequence some 0.75 seconds after the rear seat pilot. The front canopy jettison system functioned correctly and he exited the aircraft when the aircraft was almost fully inverted. The system functioned correctly but the pilot struck the top of a 15 metre high tree whilst still attached to the seat and impacted the ground some 1200 metres from the point of collision almost directly below the track of the fuselage. At impact the man/seat separation sequence was occurring with the parachute streamed but not deployed and the pilot still attached to the seat.

1.16 Tests and research

1.16.1 Terrain obscuration

From the start of the investigation it was apparent that the terrain surrounding the accident site could well have caused obscuration problems to an extent that it may have been impossible for the pilots of either aircraft to see the other until very shortly before the collision. In order to test this theory, another Jaguar fitted with a video camera was tasked to film the valley in which the collision had occurred. An RAF helicopter was also tasked to take still photographs of significant points.

The Jaguar flight path was deduced from a combination of the surviving pilot's recollection, eyewitness evidence and the crash position. The Cessna's flight path was deduced from an analysis of the many eyewitness reports using a matrix method. The precise altitude of the collision was unknown but from the best evidence it was judged to be 350 feet agl. For calculation purposes the speed of the Jaguar has been assumed to be 450 knots and that of the Cessna to be 85 knots.

The flight reconstruction showed that when the Jaguar approached the village of Talerddig it must have been in a right hand turn before levelling into the straight section of the valley towards Carno. Once over Talerdigg, at a speed of 450 knots, the aircraft was 20 seconds from collision. However, at this moment, assuming both aircraft to be flying at 350 feet agl, the Cessna would not have been visible to the Jaguar pilots due to high ground obscuring a direct line of sight. (see Appendix A-1). The obscuration illustration assumes a collision height of 350 feet agl and the ground over which the collision took place is 200 metres above mean sea level (656 feet).

The second obscuration illustration (see Appendix A-2) shows that the first likely unmask point *ie* the point at which either aircraft could see the other, was 10 seconds prior to the collision. The Jaguar approached the Cessna on a constant bearing of approximately 125° left of the Cessna's centre-line, *ie* from the Cessna's rear left quarter.

1.16.2 Ground features

The last recollection of the Jaguar rear seat pilot is of sighting a red telephone box situated alongside the A470 road and drawing the attention of the other pilot towards it. The aircraft was then banked slightly to the left. In order to assess whether this momentary distraction was a factor in contributing to the failure of the Jaguar pilots to see the Cessna in time to take avoidance action, an attempt to identify the location of the telephone box was made (see Appendix D). An RAF

helicopter was tasked with taking aerial photographs of all telephone boxes along the Jaguar's final flight path. The helicopter flight was carried out in similar weather conditions to those prevailing at the time of the accident.

The final flight path of the Jaguar was reported to be alongside the A470 road, with the road between 500 and 1000 metres to the Jaguar's left side. There are four red telephone boxes alongside the A 470 road between Dolfach, Talerdigg and Carno. Photographic and visual evidence from the air showed that, due to screening by trees and buildings, the only box that would have been clearly visible from along the Jaguar flight path was situated in the village of Carno. It is impossible to say precisely where the Jaguar was when the rear seat pilot sighted the telephone box. The photograph of Carno village at Appendix D, was taken from a point equivalent to 8 seconds before the collision, however it is unlikely that it could have been seen from that position. The earliest likely sighting would have been at the position marked 'X' on the photograph. At a speed of 450 knots, this point would have been 4 seconds prior to collision. However, it is also possible that the telephone box was in fact glimpsed 1 or 2 seconds later, as the Jaguar commenced a left bank to negotiate the turn into the valley beyond Carno.

1.16.3 Visual detection and recognition

Statistics show that the majority of mid-air collisions occur in good weather and good visibility. The problems of the visual detection of another aircraft and the recognition that it is on a collision course have long been recognised and much research has been carried out into ways of avoiding such accidents. In order to assess the probability of detection in the circumstances of this accident, expert advice was sought from the Principal Psychologist of the Institute of Aviation Medicine (IAM). His report is included at Appendix E.

1.17 Additional information

1.17.1 Military Low Flying

Current military tactics require that allied air forces should be able to fly very low and very fast. The RAF has, therefore, a requirement to train its pilots in the low level reconnaissance and attack roles. Since 1979 the whole of the United Kingdom (UK) has in principle been open to low flying, but in practice environmental and safety restrictions halve the airspace available. Major conurbations and the controlled airspace available for the protection of public transport aircraft are excluded. For administrative convenience, the country is divided into 19 Low Flying Areas (LFA), not evidently linked to any geographical divisions on the ground. In the UK, military fast jets are considered

to be low flying when they are at less than 2000 feet msd, that is to say less than 2000 feet from the ground, water or any object except another aircraft flying in the same formation. The lowest height at which military jets are normally permitted to fly is 250 feet msd. However, most low flying training takes place between 250 and 600 feet msd and is carried out on weekdays, during daylight and in good weather. Except in the Highland Restricted Area, which is set aside on a regular basis for low flying in limited visibility using terrain following radar, all low flying by day is in Visual Meteorological Conditions, that is pilots must be able to fly by visual reference to the ground.

All military low flying in the UK, whether by UK or foreign air forces is subject to a code of rules and regulations which are laid down in the United Kingdom Military Low Flying Handbook. This handbook, which is regularly updated, describes the regulations which currently apply in each low flying area and lists the large number of sites which, for a variety of reasons, are to be avoided. It is a classified document and therefore not available to civil commercial or general aviation operators and pilots. Some of these details from the handbook are printed on the military low flying charts, which also include traffic flow directional arrows so that military aircraft in transit between the low flying areas may be kept separate from each other. These charts, although not formally classified, are marked 'For Official Use Only' and are also not generally available to civil aviation operators and pilots. In addition, details of temporary avoidance areas and other low flying activity are circulated on a daily basis by a system of NOTAMS.

Each low flying sortie is required to be meticulously planned and then notified several hours in advance to a central co-ordinating authority, normally the London Air Traffic Control Centre (Military) Tactical Booking Centre (TBC) at West Drayton. This centre co-ordinates military low flying sorties and also provides co–ordination with civil aircraft whose flights have been notified in accordance with the CANP procedures described in paragraph 1.17.3.

The organisation and control of military low flying and its co-ordination with civil aviation is under constant review and the TBC anticipate the use of a new Automated Low Flying Enquiry and Notification System (ALFENS). This computerised system will provide up to date information on the UK low flying system at all fast jet operating bases. It is expected to become operational in Spring 1994.

1.17.2 *Volume of low flying*

Published statistics concerning low flying movements cannot accurately portray the level or intensity of activity in particular low flying areas. They do not account for the fact that one flight lasting an hour may take place in one low flying area generating one movement, whilst another flight lasting only a few minutes may cross three small areas generating three movements. A more meaningful measure of the level of military low flying activity is shown by the numbers of flights made. Precise figures are not available, however, the following table shows estimates of low flying sorties flown during the period 1988-91;

Year:	1987	1988	1989	1990
Sorties:	146,500	151,000	140,000	141,000

Of these totals about two thirds were flights by fast jets and one third other aircraft including helicopters.

On 14 October 1991 HM Government announced that, due to proposed changes in the structure of the armed forces, low flying flights over the UK by military jet aircraft would be progressively reduced by about 30% over the following three years.

1.17.3 *Low Level Civil Aircraft Notification Procedure (CANP)*

Some civil aircraft operators are authorised to carry out aerial work at very low heights. These flights generally take place in the Flight Information Regions outside Controlled Airspace and at low levels where a Radar Advisory Service cannot be provided. Collision avoidance must necessarily be based on the 'see and be seen' principle, assisted as far as is possible by information on known traffic. Although military aircraft are considered to be low flying when they are less than 2000 feet msd, it is not practicable to disseminate information on all civil aircraft operating at that height or below. However the greatest conflict of interest is considered to occur at or below 500 feet agl where the majority of low level operations take place. Therefore, a system exists to collect information on civil aircraft engaged in aerial work within this height band, *ie* at or below 500 ft agl and to distribute it to military operators to assist in planned avoidance. This system, which is voluntary, is known as CANP and is fully described in the United Kingdom Air Pilot (UK AIP), Rules of the Air and Air Traffic Services (RAC) 3-10-1. (See Appendix F)

The CANP procedures contained at Appendix F were those in force at the time of the accident. These procedures were re-issued as RAC 3-9-4-1 effective from 14 November 1991 with minor editorial changes only. Revised procedures were introduced from 9 January 1992, and published in the Aeronautical Information Circular 2/1992. The essential difference in these procedures was that, for a trial period of six months commencing 9 January 1992, the maximum operating height for notification of flights under CANP was raised from 500 feet to 1000 feet agl. The Circular also contains the following note:- *"Due to the flexible nature of their task, pilots of aircraft engaged upon powerline/pipeline inspections are often unable to accurately predict Estimated Times of Arrival (ETAs) at specified positions along intended routes. Consequently, information pertaining to authorised inspection of powerlines and pipelines is of little value to military aircrew and is not normally accepted."*

1.17.4 CANP notification usage

The CANP notification procedures were introduced in 1975-1976 following an investigation into a low level mid-air collision between an RAF Phantom jet and a civil Piper PA25 aircraft that had approval to operate below 500 feet on an aerial application flight. Initial response from civil operators was encouraging and notification of civil low level flights rose to a peak of 4,526 flights notified in 1987. Thereafter the number of notifications has decreased significantly, as shown below:

Year:	1988	1989	1990
Notifications:	3,219	548	412

It should be noted that since the peak figure recorded in 1987 there has been a significant reduction in flying for the purpose of aerial application (crop spraying).

1.17.5 Mid-air collision statistics

Since 9 August 1974 there have been three mid-air collisions between low flying military jets and civil aircraft which have resulted in fatalities. These are listed as follows:

9 August 1974	RAF Phantom FGR2 / Piper PA25 Fordham Fen, Norfolk.
29 February 1984	USAF A10 / Cessna 152 Hardwick, Norfolk.
29 August 1991	RAF Jaguar TA2 / Cessna 152 Carno, Wales.

The collisions resulted in six fatalities. No persons were injured on the ground. There have also been a number of collisions involving military aircraft only, resulting in a number of changes to the UK low flying system and its operation.

The data base maintained by the Safety Data and Analysis Unit of the Safety Regulation Group, CAA includes details of of mid-air collisions between civil light aircraft that have occurred since January 1976. From that date until August 1991 there have been 28 mid-air collisions involving UK registered light aircraft, resulting in 43 fatalities with no injuries to persons on the ground. These figures do not include collisions on the ground when one aircraft has been in the process of taking off or landing.

1.17.6 Airmiss statistics

Whenever an Airmiss is reported, the circumstances are investigated by the Joint Airmiss Section (JAS), a department within the National Air Traffic Services (NATS) which is a joint civil/military organisation. Once the evidence has been assembled by JAS it is submitted to the Joint Airmiss Working Group (JAWG) who assess the degree of risk inherent in each occurrence. The degree of risk is assessed in accordance with the International Civil Aviation Organisation (ICAO) guide lines and categorised as follows:

Category 'A' - Actual risk of collision
Category 'B' - Possible risk of collision
Category 'C' - Other reports with no assessed risk of collision

JAS maintains a data base of all Airmisses and, after the JAWG assessment, each Airmiss is coded under a wide range of parameters including aircraft types, the location and geometry of the incidents, passing distance, degree of risk and cause. The data base was interrogated to provide details of all Airmisses during a three year period between low flying military and civil general aviation aircraft at 2000 feet and below and to further sub-divide the figures to those Airmisses reported within the military low flying areas. The figures are for the three years commencing on 1 March 1988 and ending 28 February 1991 and include Category 'A' and 'B' risks only.

Years:	1988-89	1989-90	1990-91
Category 'A'	9 (4)[3]	7 (2)	9 (6)
Category 'B'	22 (11)	13 (7)	19 (11)

[3] Figures in brackets refer to airmisses reported only within military low flying areas

1.17.7 *Registered owner*

The registered owner of the Cessna was Skyviews & General Limited. The company operated 12 Cessna 150/152 aircraft and part of their business was to arrange for the photography of properties from the air with a view to selling the prints to the property owners or to the general public. For this activity the company was not required, under existing legislation, to hold an Air Operator's Certificate (AOC). An aircraft registered in the UK is not permitted to fly for the purpose of public transport unless the operator holds an AOC. The regulations in full are contained in the Air Navigation Order (ANO), Part II, Article 6.

For aerial photography flights the company provided the pilot with a fully maintained aircraft and paid the required fuel and operational costs. They also issued the pilots with trigger operated hand held cameras fitted with a 300 millimetre lens and a supply of films. Evidence retrieved from the wreckage of the Cessna showed that the company also provided maps on which the areas that they required to be photographed were highlighted. The pilots were issued with the company general rules which were printed on a single sheet of A4 paper. These rules included the instruction: *"when flying open country areas i.e. five hundred feet rule areas never fly below six hundred feet from the ground using a 300 mm lens"*. The company also forbade the carriage of passengers without their specific permission. Pilots were not directly employed by the company and they were not remunerated on a formal basis for flying the aircraft, however they did receive a percentage of the profits accrued from the sales of the photographs that they had taken and in relation to the quality of the prints.

During the period 11 April 1991 to 20 September 1991, 31 allegations of offences under the ANO by pilots operating aircraft owned by Skyviews and General Limited have been noted by the CAA Aviation Regulations Enforcement and Investigation Branch. In the majority of cases the alleged offence includes contravention of Rule 5 - Low Flying (see para 1.17.8 below).

1.17.8 *Relevant legislation*

1.17.8.1 *Aerial Work*

The CAA has for some time been considering ways in which legislation might be changed to remove uncertainties that have arisen in the past from interpretation of the existing definitions of public transport or aerial work. Article 107 (1) of the ANO defines aerial work as: *"any purpose (other than public transport) for which an aircraft is flown if valuable consideration is given or promised in respect of the flight or the purpose of the flight"*. ICAO Annex 6 Operation of Aircraft defines aerial work thus: "*An aircraft operation in which an aircraft is used for specialised*

services such as agriculture, construction, photography, surveying, observation and patrol, search and rescue, aerial advertisment, etc". Rationalisation of these different definitions has yet to be achieved but may well be necessary in the context of European harmonisation of legislation governing civil aviation.

1.17.8.2 Low Flying

The Rules of the Air Regulations 1991 are published in full in the ANO, Section 2. The following paragraphs include extracts from the Rules which are considered to be pertinent to this investigation:

"Low Flying

5 (1) Subject to the provisions of paragraphs (2) and (3):

(a) An aircraft other than a helicopter shall not fly over any congested area of a city, town or settlement below:

(i) such height as would enable the aircraft to alight clear of the area and without danger to persons or property on the surface, in the event of failure of a power unit and if such an aircraft is towing a banner such height shall be calculated on the basis that the banner shall not be dropped within the congested area; or

(ii) a height of 1500 feet above the highest fixed object within 2000 feet of the aircraft:

whichever is the higher.

.....

(e) An aircraft shall not fly closer than 500 feet to any person, vessel, vehicle or structure."

"Rules for avoiding aerial collisions

17 (1) General

(a) Notwithstanding that the flight is being made with air traffic control clearance it shall remain the duty of the commander of an aircraft to take all possible measures to ensure that his aircraft does not collide with another aircraft."

(2) Converging

(b)....when two aircraft are converging in the air at approximately the same altitude, the aircraft which has the other on its right shall give way:

(4) Overtaking

An aircraft which is being overtaken in the air shall have right-of-way and the overtaking aircraft, whether climbing, descending or in horizontal flight, shall keep out of the way of the other aircraft by altering course to the right, and shall not cease to keep out of the way of the other aircraft until that other aircraft has been passed and is clear, notwithstanding any change in the positions of the two aircraft."

Air Navigation Order 1989 - Part III - Article 51

"**51** A person shall not recklessly or negligently cause or permit an aircraft to endanger any person or property."

Air Navigation Order 1989 - Schedule 8 - Part A-Licences[4]

"**1 AEROPLANE PILOTS**

Private Pilot's Licence (Aeroplanes)

Minimum Age - 17 years

No maximum period of validity

Privileges:

The holder of the licence shall be entitled to fly as pilot in command or co-pilot of an aeroplane of any of the types specified or otherwise falling within the aircraft rating included in the licence:

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4 There are exceptions to the stated conditions and holders of Private Pilot's Licences are permitted to carry out certain aerial work such as flying instruction, towing a glider in flight, and the dropping of parachutists and to receive remuneration for these services. Full details have not been included as not being relevant to this accident.

Provided that:

(a) he shall not fly such an aeroplane for the purpose of public transport or aerial work.

(b) he shall not receive any remuneration for his services as a pilot."

1.18 New investigation techniques

None.

2 Analysis

In accordance with Military Regulations, an RAF Board of Inquiry was convened and the AAIB investigation team received full co-operation from the Board. The civil investigation of this accident was carried out under the provisions of The Air Navigation (Investigation of Air Accidents involving Civil and Military Aircraft or Installations) Regulations 1986. Regulation 4 states: "The fundamental purpose of investigating accidents under these Regulations shall be to determine the circumstances and causes of the accident with a view to the preservation of life and the avoidance of accidents in the future; it is not the purpose to apportion blame or liability". The investigation was therefore directed only towards the circumstances that resulted in the two aircraft colliding in free airspace. It also considered safety measures that might prevent further such occurrences. The investigation was not directed towards an examination of military fast jet low flying policy or its effect on the environment. The House of Commons Defence Committee carried out an examination of Low Flying during the 1989-90 Session and its report was ordered by the House of Commons to be printed on 28 March 1990. Some of the information included in this report is derived from that document.

2.1 General

2.1.1 Flight conduct

The collision occurred in fine weather and good visibility when both aircraft were flying in uncontrolled airspace and neither aircraft was operating under positive air traffic control. At the estimated collision height of 350 feet agl both aircraft would have been below any local area radar cover, thus an ATC radar advisory service was not possible neither was the Jaguar equipped with airborne radar that could detect the presence of other aircraft. Thus at the time of the collision the only recognition of a potential hazard available to the pilots of both aircraft was by visual detection. 'See and avoid' were the collision avoidance criteria in effect at the time.

The evidence indicates that the Jaguar crew were alert and carrying out their training flight in a responsible and professional manner. The HUD was in use with the radalt displayed so that both pilots of the Jaguar were able to maintain a good forward look out whilst at the same time monitoring the aircraft's height above the ground. The instrumentation was such that they did not have the distraction of having to look down and inside their cockpits to monitor altitude by reference to basic flight instrument panels. As operational military fast jet pilots they were also well trained and well practiced in maintaining a good look out at all times. The rear seat pilot of the Jaguar recalls that, when the aircraft entered the

valley over Talerdigg alongside the A470 road, he was concentrating his look out in the forward hemisphere and did not see any other aircraft at that stage. At the same time both pilots would have been monitoring the aircraft's msd from the ground immediately below the aircraft and the walls of the valley to either side.

The Jaguar pilots appear to have planned their flight carefully and their flight authorisation shows that it was certainly checked with the TBC and that there were no notifications of low level civil aircraft activity along their planned route. The nature of the terrain in the low level sector of the flight was such that it was not an area in which they would reasonably have expected to encounter a single engine aircraft at extremely low level. The momentary distraction from maintaining a forward look out whilst they banked the aircraft to the left in order to identify the telephone box is not considered to be a causal factor of the accident. This moment could well have been coincidental with the need to initiate a full left turn in order to turn into the next valley. At the time that this happened it is likely that the collision was already unavoidable.

In contrast to the careful planning by the Jaguar pilots, there is no evidence that the Cessna pilot applied similar attention to detail. Many of the aerial photography flights that he had flown from Halfpenny Green during the previous five months had been over Mid and South Wales and therefore he must have been well aware of the type of terrain over which he was flying. In the event of an engine failure at low level his chances of carrying out a successful forced landing must be considered to be remote and his survival could well have depended upon an ATC unit alerting the emergency services. It must be presumed that he was aware that he was flying over areas that were frequently used by low level military fast jets. His flying record shows that he was well experienced in taking aerial photographs whilst flying the aircraft solo and he must have realised that this activity was detrimental to his ability to keep a good look out for other aircraft. Yet despite these factors he did not choose to inform any ATC authority of his intended route or of his expected return time. Equally, he did not notify his intended flight to the military authorities by utilising the CANP. It is not possible to establish whether this was due to his ignorance of the procedure or an unwillingness to draw official attention to his low flying activity. Whatever the reason, there is little doubt that had he used the CANP, the Jaguar would not have been cleared to fly at low level in the area in which the Cessna was operating. The lack of pre-flight planning and the poor airmanship displayed by the Cessna pilot are therefore considered to be contributory factors in the circumstances of this accident.

2.1.2 *Collision geometry and visual acquisition probability*

The detailed examination of the wreckage of both aircraft together with eyewitness evidence showed that, at the moment of impact, the Cessna was probably flying with the wings level and pitched slightly nose up in a shallow climb. This nose up attitude could have further obscured the view of the approaching Jaguar due to the aft edge of the cabin roof and the trailing edge of the left wing. The Jaguar was then in level flight with the left wing down at an angle of between 30° and 35°. The relative collision bearings showed that the Cessna was about 10° right of the Jaguar's centre line and the Jaguar approaching the Cessna from about 125° left of its centre line position. This collision geometry is illustrated from two aspects at Appendix C.

The probability of visual detection of other aircraft in time to take avoiding action is described in detail in Appendix E. In this instance there were additional factors such as terrain screening which exacerbated the problem. The Cessna was struck from behind in its 8 o'clock position. This is not an area where the pilot could reasonably maintain a look out for other aircraft and in any case the rearward view in that quarter is blocked by the rear canopy strut. There was little chance that the Cessna pilot could have seen the Jaguar.

The effect of terrain masking meant that there was virtually no chance of the Jaguar pilots being able to see the Cessna until some 10 seconds prior to the collision. Even at this late stage the chances of detection were reduced as the location of the Cessna would have been behind the Jaguar's forward window/HUD strut. It was probable that the Jaguar crew were attending to ground features to the left of track anticipating a left turn into the next valley.

2.1.3 *Rules of the Air*

From the above it is clear that the collision occurred because neither aircraft had the information necessary to take avoiding action in time to prevent it. Under The Rules of the Air Regulations 1991, Rule 17 'Rules for avoiding aerial collisions' (see paragraph 1.17.8.2) there is little doubt that the Cessna, by virtue of the fact that it was being overtaken and was to the right of the Jaguar, had right of way on both counts. However, this literal interpretation of the rules can only have any validity if the overtaking aircraft is in visual contact with the other. As well as the factors mentioned in the previous paragraph, the surviving pilot of the Jaguar is sure that the Cessna was never sighted, so to argue right of way for the Cessna is irrelevant.

2.2 Safety record, statistics and future trends

Records of mid-air collisions, airmisses and related safety statistics are important air safety indicators. Although the increasing incidence of collisions between military aircraft is a cause of concern, since 1974 there have been only three collisions between military and civil aircraft and none of these has caused any injuries to persons on the ground although some damage to property has occurred. Since 1976 there have been 28 mid-air collisions involving UK registered civil light aircraft. No statistics are available to relate these collision rates to the total number of hours flown[5], however they do indicate that the accident rate of collisions between military aircraft and civil light aircraft is low. In fact there have been more collisions involving only civil aircraft, although again there are no statistics to relate these to the total number of hours flown. There have been no mid-air collisions involving military aircraft and public transport aircraft.

Study of Airmiss statistics shows a similar pattern. The annual rate of Category 'A' Airmisses (actual risk of collision) reported between military and civil aircraft at 2000 feet agl or below has remained in single figures for the past three years, whilst those reported exclusively within the military low flying areas show an even lower rate. The safety record is good and, with the proposed reduction in military low flying that has recently been announced, may be expected to remain so.

The most common factor that contributes to the majority of mid-air collisions and airmisses is the failure of either one or more pilots to see and recognise another aircraft and perceive that there is a potential collision hazard in time to take appropriate avoiding action. One way of alleviating this problem would be to provide pilots with more information than is currently available on the movements of other aircraft so that they may be able to concentrate their look out in pre-warned areas of high traffic activity.

2.3 Civil / Military low flying co-ordination and awareness

2.3.1 Information on planned low flying

The problems and the probabilities of pilots being able to sight other aircraft at low level in time to avoid a potential collision are well described at Appendix E. As it is not realistically possible to ensure that at all times low flying military and civil aircraft are kept totally apart from each other, a practical method of reducing the chance of collisions may be achieved by improving the existing notification

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5 The CAA estimate that the hours flown by civil aircraft under 5700 kg maximum weight in the period 1976 to 1991 are approximately 8.89 million

system and providing civil operators with readily obtainable information about areas of high military aircraft activity so that they may have the opportunity to avoid them. At present the distribution of information appears to be somewhat 'one way'. Civil operators may notify their low level flights using the CANP and military flights will not normally be routed into the areas so notified. However, civil transit flights, many of which will be carried out below 2000 feet agl, do not have access to even basic information concerning military activity. Where unusual levels of military activity are planned, NOTAM information is regularly transmitted. However, many private operators do not have ready access to this type of information. It is therefore worthwhile to consider methods of improving the dissemination of this type of information and ensuring wider access to it.

2.3.2 CANP

The CANP, as in use at the time of the accident, was available to civil operators engaged in aerial work or similar at 500 feet or below. However, because of the large areas involved it was not available for pipeline or cable surveys flights, and some types of aerial application. The use of this procedure has declined sharply in recent years, reducing from 3,219 notifications recorded during 1988 to 412 notifications in 1990. A major reasons for this is no doubt the significant reduction in aerial work, particularly with regard to crop spraying, that has occurred since 1988. It may also be the case that the good safety record of aircraft operating at low level has given rise to some complacency, which has allowed the system to become under utilised. Whatever the overall reasons for the decline in the utilisation of CANP, it is certainly considered to be a system that is worth preserving. It is therefore recommended that the Civil Aviation Authority and Ministry of Defence should ensure wider publicity of CANP procedures and restate its safety benefit to civil aircraft operators. It would be useful if civil operators were reminded that the higher they are able to operate their aircraft, the less likely are they to find themselves in confliction with low flying military fast jets. Since this accident the CAA has published articles concerning the CANP procedure in the General Aviation Safety Information Leaflets (GASILs) 10/91 and 1/92. In addition, GASIL 11/91 contained a safety leaflet advising pilots of light aircraft to "whenever possible stay above 1000 feet agl or, if flying below 1000 feet agl, maintain a good look out for military traffic". This safety leaflet also carried a reminder of the CANP procedure and articles regarding CANP have also appeared in some General Aviation periodicals.

2.3.3 Regulations

Military aircraft are considered to be low flying when they are operating at less than 2000 feet msd, although most low flying training takes place between 250 and 600 feet msd. At the time of the accident the height criterion for civil

operators to notify their flights in accordance with CANP was 500 feet agl and below. The collision occurred at an estimated height of 350 feet agl, when the Cessna pilot was probably contravening the Low Flying Rule 5 (1)(e), in that he was flying closer than 500 feet to persons and structures. Neither the Rule itself nor any related legislation requires or suggests that a civil aircraft shall not fly at less than 500 feet agl unless in doing so it would come closer than 500 feet to a person, vessel, vehicle or structure. However, subject to the limitations imposed by ATC regulations and the Rules of the Air, civil pilots of air photography flights and the like may operate at 500 feet and above wherever they choose and without notification. There remains therefore a potential for conflictions between military aircraft flying between 250 and 600 feet msd and civil operators flying at between 500 and 600 feet agl. Civil operators may only carry out aerial work below 500 feet with specific CAA dispensation from Rule 5 (1) (e). However no dispensation is required to operate at 500 feet and this investigation has shown that a considerable amount of civil aviation, in particular aerial photography flying is planned to take place at that height.

2.3.4 CANP usage and operational considerations

The reduction in CANP notifications over the last few years suggests that the CANP system is not over loaded and that there is scope for its wider use. The decision to raise the CANP notification level to 1000 feet agl is sensible and hopefully it will encourage wider use than has occurred of late. The exclusion of aircraft engaged in aerial surveys of powerlines and pipelines is difficult to understand. The problems of the prediction of accurate ETAs in this type of flying are appreciated, but it is considered that information concerning the areas where these types of operation are planned could prove beneficial to flight safety if only by alerting military pilots to maintain a look out for these aircraft. Accordingly it is recommended that the extension of the CANP system to encompass civil aerial work carried out at or below 1000 feet agl should be maintained and its scope widened to include all forms of aerial work at these levels.

If collision risks, particularly at low level, are to be minimised the responsibility for achieving this cannot be laid entirely on the military authorities. Civil operators and pilots have an equally important part to play. It is not practicable to establish and subsequently employ ATC traffic information on all civil aircraft below 2000 feet agl, where a great deal of general aviation takes place. Furthermore, most of this type of aviation tends to take place in free airspace where 'see and avoid' is a primary collision avoidance factor. Maintaining a good all round look out at all times is a discipline that has to be practiced and is sometimes difficult to achieve. Cockpit workload can prove detrimental to this purpose. It may be possible, however, to alleviate some of the safety problems

associated with low level flying by making information concerning military activity more readily available to general aviation pilots and thus enable them to plan their flights more safely by avoiding high density areas and choke points and thereby reducing the risks of collision.

The majority of military low flying sorties must be notified to the London Air Traffic Control Centre (Military) TBC which acts as a central co-ordinating authority and ensures that the low flying areas and link routes do not get over crowded. CANP notifications are also co-ordinated by the Centre which thus has continual and current information on the majority of low flying that is taking place throughout the UK and details of where the activity is likely to be the highest. If this information was available to all civil pilots it would afford them the opportunity to avoid high density areas or transit them at a higher and therefore safer level. As many civil pilots and operators do not have access to the NOTAM system, this information would reach its widest audience if transmitted by telephone. It is therefore recommended that together with the Ministry of Defence, NATS should examine methods of making available information, on a daily basis, concerning areas where high intensity military low flying will take place, so that civil aircraft operators may plan to avoid or overfly these areas. In the long term it is anticipated that the introduction of ALFENS may create an opportunity for a more comprehensive briefing service to be available to civil pilots. It is desirable that this be kept under constant review.

2.3.5 *Aeronautical charts*

In order to separate low flying military aircraft from each other, the military low flying charts include uni-directional flow arrows which pilots are expected to follow. They thus indicate not only where low flying aircraft are likely to be, but also the direction in which they are most likely to be flying. The low flying charts already contain a lot of detail, however the flow arrows are not intrusive and are obviously useful reminders of where and in which direction pilots should concentrate their look out. The majority of civil general aviation pilots navigate their aircraft using the Aeronautical Chart ICAO 1: 500,000. These charts also contain much necessary detail, including the location of all RAF flying stations, and may be in some danger of becoming over cluttered. Nevertheless it is considered that it would benefit flight safety if some minor modifications and additions were made. It is therefore recommended that the Civil Aviation Authority should require that military flow directional arrows should be published on civil aeronautical charts and that those RAF stations that operate fast jets should be 'high-lighted'. Military fast jets may operate from any suitable airfield and not just those where the aircraft are normally based. All operational military airfields are notified as having an Aerodrome Traffic Zone, a Military Aerodrome Traffic Zone which is advisory to civil pilots and an associated air traffic service

which is available to civil pilots. It is considered that such 'high-lighting' action would remind pilots where to concentrate their look out and also remind them that the higher they are able to fly the less likely they are to conflict with low flying fast jets.

2.4 Aerial photography

2.4.1 Aerial photography of a commercial nature

This investigation has revealed that there is currently a significant amount of low level aerial photography flying for commercial purposes taking place throughout the UK. The registered owners of the Cessna also owned 12 other aircraft of similar type and they were likely all to have been operated in similar fashion, that is to say flown at low level by solo pilots who also took the photographs. There are two aspects in this type of operation that give rise to some immediate concern. Firstly, the flight safety implications and secondly the question of aerial work.

2.4.2 Single pilot /photographer operation

Two fundamental responsibilities that are vested in all pilots are the requirements that they do not permit their aircraft at any time to endanger any person or property and also that they take all possible measures to ensure that their aircraft does not collide with another aircraft. In order to carry out these responsibilities it is important that pilots remain as alert as is possible and are free from unnecessary distractions. Although the practice of using a hand held camera whilst flying a light aircraft is apparently widespread, it cannot be considered either prudent or in accordance with good airmanship. A pilot who is manually flying a light aircraft with one hand whilst operating a camera through a side cabin window with his other hand cannot be considered to be able to maintain a proper look out for other traffic and, in these circumstances, should he incidentally perceive a possible confliction, his ability to take prompt avoiding action must be in serious doubt.

In addition, aerial photography of properties for commercial purposes, of necessity, require that aircraft are flown close to those properties using the relatively unsophisticated camera equipment that is common. There is no question that fully stabilised, fixed mount cameras with appropriate lenses would lessen this requirement for low flying, although at greater cost. Under present low flying legislation and without a CAA exemption an aircraft may be flown to within 500 feet of the properties. The temptation to fly at an even lower level in order to obtain a better picture is always present. Pilots' abilities to cope safely with an engine failure, bird-strike or even difficult wind conditions and down draughts whilst flying at such low levels must also be open to question. A second pilot, dedicated camera operator and more suitable equipment would seem to be a much safer option.

2.4.3 *Aerial work*

The second point of concern is the question of the remuneration of pilots who are utilising the privileges of a Private Pilot's Licence whilst flying light aircraft in order to take photographs of properties for commercial purposes. Article 107 (1) of the ANO defines aerial work as: *"any purpose (other than public transport) for which an aircraft is flown if valuable consideration is given or promised in respect of the flight or the purpose of the flight"*. However, ANO Schedule 8 allows that PPL holders may receive remuneration for flying aircraft under certain circumstances, such as qualified flying instruction, towing a glider and the dropping of parachutists. Aerial photography flights, on which a pilot does not receive direct remuneration for flying an aircraft but does accept a commission from the profits accrued from the sales that he has generated, would seem to fall into an ill-defined area of legislation. The operation of such flights may well be permissible under the present legislation but it remains questionable as to whether they fall within the spirit of the legislation.

It is apparent that the UK definition of aerial work is imprecise and requires clarification. The current definition can entail a process of elimination, *ie* if it is not public transport but valuable consideration is involved then it is likely to be aerial work. The ICAO definition is much more specific in the types of operation that should be classified as aerial work. It is therefore recommended the CAA should re-examine the UK definition of aerial work and ensure that the legislation allows that the activities of operators engaged in aerial photography flights of a commercial nature may be properly and safely regulated. By recognising the activity properly as aerial work, as opposed to an extension of private flying, a greater measure of regulation should be possible.

3 Conclusions

(a) Findings

(i) The Jaguar had been properly maintained and its documentation was in order. The Cessna had been regularly maintained but was overdue for a routine inspection which was required under its Certificate of Airworthiness.

(ii) There were no significant defects in either aircraft that could have contributed to the cause of the accident.

(iii) There was no evidence of any medical factors which might have caused or contributed to the accident.

(iv) Both of the Jaguar pilots were well experienced and properly qualified to conduct the flight.

(v) The Cessna pilot was properly qualified to carry out a private flight, which included the taking of photographs. He was not licensed to engage in aerial work or public transport which thus precluded his use of a dedicated photographer.

(vi) The Jaguar was flown in accordance with RAF low flying regulations.

(vii) The two aircraft collided at an altitude of between 300 and 400 feet agl.

(viii) At the collision altitude, the Cessna pilot was contravening Rule 5(1)(e) of the ANO Rules of the Air in that the aircraft was within 500 feet of a "person, vessel, vehicle or structure".

(ix) The pilot of the Cessna did not notify his flight in accordance with CANP.

(x) Had the Cessna pilot notified his flight in accordance with CANP the Jaguar would not have been flying in the same area at the time of the collision.

(b) Causes

The following causal factors were identified:

(i) The crew of the Jaguar and the pilot of the Cessna did not see each other's aircraft in time to take avoiding action.

(ii) Both aircraft were flying at a height which was less than 500 feet agl.

(iii) The Cessna pilot had not notified the flight in accordance with CANP

4 Safety Recommendations

The following safety recommendations were made during the course of the investigation.

Recommendation 92-5

The Civil Aviation Authority and Ministry of Defence should ensure wider publicity of CANP procedures and restate its safety benefit to civil aircraft operators.

Recommendation 92-6

The trial extension of the CANP system to encompass civil aerial work carried out at or below 1000 feet agl should be maintained and its scope widened to include all forms of aerial work at these levels.

Recommendation 92-7

Together with the Ministry of Defence, NATS should examine methods of making available, on a daily basis, information concerning areas where high intensity military low flying will take place, so that civil operators may plan to avoid or overfly these areas.

Recommendation 92-8

Military flow directional arrows should be published on civil aeronautical charts and that those RAF stations that operate fast jets should be 'high-lighted'.

Recommendation 92-9

The CAA should re-examine the UK definition of aerial work and ensure that the legislation allows that the activities of operators engaged in aerial photography flights of a commercial nature may be properly and safely regulated.

R StJ Whidborne
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The CAA's responses to these Safety Recommendations are published in CAA Follow-up Action on Accident report No 2/92.