ACCIDENT

Aircraft Type and Registration:	1) SZD-51-1 'Junior' glider, G-CLJK 2) Cessna 150L, G-CSFC
No & Type of Engines:	1) None 2) One Continental Motors O-200-A piston engine
Year of Manufacture:	1) 1991 2) 1973
Date & Time (UTC):	4 December 2016 at 1231 hrs
Location:	7.5 nm south of Leicester Airport
Type of Flight:	1) Private 2) Training
Persons on Board:	1) Crew - 1 Passengers - None 2) Crew - 2 Passengers - None
Injuries:	1) Crew - 1 (Fatal) Passengers - N/A 2) Crew - 2 Passengers - N/A
Nature of Damage:	G-CLJK aircraft destroyed, G-CSFC major damage to right wing
Commander's Licence:	1) Glider Pilot's Licence 2) Commercial Pilot's Licence
Commander's Age:	1) 70 years 2) 26 years
Commander's Flying Experience: (G-CLJK)	1,054 hours (of which 1,048 were on gliders) Last 90 days - 12.5 hours Last 28 days - 4 hours
Commander's Flying Experience: (G-CSFC)	1,124 hours (of which 815 were on type) Last 90 days - 112 hours Last 28 days - 26 hours
Information Source:	AAIB Field Investigation

Synopsis

Two aircraft collided in VFR conditions in Class G airspace; neither aircraft was receiving an ATC service. The investigation concluded that neither pilot saw the other aircraft in sufficient time to take effective avoiding action.

History of the flights

Cessna 150 L (G-CSFC)

The aircraft was engaged on a training flight, with a flying instructor and his student on board. The purpose of the flight was to conduct a navigation exercise from Hinton-in-the-Hedges Airfield, where the aircraft was based, to Leicester Airport. The instructor first flew a flight in a different flying school aircraft before joining his student for the flight in G-CSFC to Leicester. The flying instructor had regularly flown from Leicester. In the briefing he informed the student about the gliding activity at the nearby Husbands Bosworth Airfield as the planned route to Leicester would take the aircraft close to, but to the west of, the airfield.

The aircraft took off at 1206 hrs and flew at approximately 2,500 ft on a track of about 025° (M). The weather was described as good, and visibility was reasonable, although this was reduced when flying toward the low sun. During the flight the sun was behind the aircraft. After takeoff, they contacted Coventry Airport ATC and requested a basic service[1], which was provided.

As the aircraft approached the area of Husbands Bosworth Airfield, it was to the east of its intended track, such that the airfield was on the aircraft's left hand side. The student pilot altered heading which took them between the airfield and the town of Market Harborough.

During the flight, the pilots had been monitoring other light aircraft flying in their vicinity and in a similar direction. They were aware of two aircraft to their right and a further aircraft to their left. These aircraft were not close enough to cause concern, but did require monitoring in case their flight paths changed. The pilots also recalled seeing a light helicopter crossing their track ahead, although they were not sure whether this was before or immediately after the accident.

When the aircraft was 7.5 nm south of Leicester Airport, the student pilot looked down at the radio, tuned it to the Leicester air/ground frequency and then transmitted an initial radio call to the operator. He recalled looking at the altimeter to check the altitude and then, on looking up, became aware of the glider almost directly ahead at the same level. The instructor recalled that he had been looking at the aircraft to their right when, on looking ahead, he too became aware of the glider directly ahead. Both pilots of G-CSFC thought that they had become aware of the glider simultaneously.

The glider was seen for only a very short period of time before the instructor made an instinctive control input to pitch the aircraft nose-down and roll left. Both pilots in G-CSFC described the glider as appearing nose-on, in substantially level flight (although the student thought it might have been in a slight nose-down attitude), and at exactly the same altitude. When seen, the glider was at very close range, such that the instructor felt he would have been able to distinguish fine detail on it had the scene been unmoving. The instructor considered that the two aircraft would have collided nose-on had he not taken immediate avoiding action. Neither pilot recalled seeing the glider start any evasive manoeuvring during the short time it was in their view.

Shortly after, there was a loud bang, and it was evident that the aircraft had collided with

Footnote

[1] A Basic Service is an Air Traffic Service provided for the purpose of providing advice and information useful for the safe and efficient conduct of flights. This may include weather information, serviceability of facilities, aerodrome conditions, general airspace activity, and any other information likely to affect safety. The controller may provide traffic information, but the avoidance of other traffic remains solely the pilot's responsibility.

the glider. The instructor then regained straight and level flight, although this required a significant amount of roll control input. From the required control response, and after a visual inspection, the pilots were aware that the aircraft had suffered damage to its right wing. The aircraft continued to Leicester Airport and the instructor reported the collision to the air/ground operator. The aircraft landed without further incident.

Glider SZD-51-1 'Junior' (G-CLJK)

On the day of the accident, the pilot of G-CLJK attended a morning briefing at Husbands Bosworth Airfield. This covered local area warnings and weather information. It also included cautions about cockpit canopy misting and the potential for poor visibility when flying into the low sun.

The weather was described by other club members who flew that day as good, and there was a very light wind from the south-east. The pilot, who was an experienced instructor, initially flew two instructional flights in an ASK 21 glider with another pilot. Both flights were reportedly uneventful.

The pilot had flown a 'Junior' before, but not recently, so he asked another club member to go over some key revision points with him. Among these, the pilot was informed that the radio was not receiving. The pilot confirmed this through a test call. The radio was not required for local flights, and radio calls from gliders are generally only made at times of high traffic density, such as during competitions, and the pilot accepted the radio unserviceability. Canopy misting was discussed and the pilot was told that it had occurred during the previous flight, but had not persisted once airborne. There was also a discussion about the glider's safety harness, which was different from that on some gliders.

The pilot took off in G-CLJK at 1217 hrs on an aerotow launch. The tug pilot reported that the aerotow was uneventful. The glider jettisoned the tow normally at about 3,700 ft, after which the tug aircraft returned directly to the airfield and landed.

The glider then flew in a generally northerly direction until it was about 4 nm north-east of Husbands Bosworth Airfield, at which point it turned right onto a steady track of about 220°(M) that took it back in the direction of the airfield. The glider's vertical profile was consistent with a normal glide descent, without any significant vertical manoeuvring. On this track, the glider was on a collision course with G-CSFC. There was about 24 seconds between finishing the turn and the collision.

Eyewitness accounts

Eyewitness accounts were obtained from occupants of a light helicopter and two light aircraft in the vicinity. Accounts were also taken from three witnesses on the ground, one of whom commented that he saw several aircraft in the area at the same time. Accounts of the airborne witnesses are summarised below.

A witness flying in the helicopter (registration G-ORBK), which had crossed ahead of the path of G-CSFC, saw the collision. He described in-flight visibility as excellent, apart from when flying toward the low sun. He saw several aircraft in the area, which he knew from experience to have a relatively high traffic density. The witness first saw the glider, in straight and level flight, at a similar height and at a range estimated to be less than 0.5 nm. The glider appeared to be flying on a south-westerly heading. He saw a powered aircraft approaching on a northerly heading. From his viewpoint, the powered aircraft appeared to be climbing. He saw another aircraft a short distance behind the first aircraft and, because of their proximity and the nearby gliding site, thought that he was actually seeing a tug aircraft and glider combination.

It quickly became apparent to the witness in G-ORBK that a collision was likely. At the point of collision, an outer section of the glider's left wing folded back, although it initially stayed attached to the aircraft. The powered aircraft dived away, whilst the glider rolled and entered a steep nose-down attitude with a rolling / spinning motion. After two to three seconds, the left outer wing section broke away.

A light aircraft (registration G-BOPA) was following a similar track to G-CSFC, but was 0.4 nm behind it and about 1,000 ft lower at the time of the collision. G-BOPA was the aircraft thought by the witness in the helicopter to be a glider. The pilot's attention was drawn to a movement ahead and to the left, which she soon realised was a glider with part of a wing missing. The glider was descending in what the pilot described as a tumbling motion, until it disappeared out of sight beneath her aircraft's left wing a short time later. The pilot did not watch the glider further, but concentrated on fixing her position in order to transmit an accurate distress call. She did not realise at that stage that the glider had been involved in a collision, and had not been aware of G-CSFC.

The pilot of the other light aircraft, (registration G-BDIE), saw the glider descending whilst spinning, and saw a section of the wing detach after about two to three rotations. He estimated the range at 0.5 to 0.75 nm, and did not see any other aircraft in the area. A passenger in G-BDIE recalled seeing a second aircraft diving away and thought he might have been seeing a glider and tug combination.

Search and rescue activities

Once G-CSFC had been established in safe flight, the instructor alerted the air/ground operator at Leicester Airport to the situation. The pilot of G-BDIE was in contact with the London Flight Information Service Officer when they witnessed the accident, and broadcast a PAN-PAN urgency call at 1231 hrs. Whilst orbiting the accident site to refine the location, the pilot was transferred to the Distress and Diversion (D&D) frequency. The D&D Cell at London Centre alerted the Aeronautical Rescue Co-ordination Centre and it was quickly established that the likely base of the glider was Husbands Bosworth Airfield which, when contacted, confirmed that the crashed glider was likely to have come from there, with one person on board.

An air ambulance landed at the accident site at 1249 hrs, where it was established that the pilot had not survived.

Recorded information

Sources of recorded information

Recorded radar information (Mode A and C[2]) was available for G-CSFC from ground-based sites located at Bovingdon, Claxby, Clee Hill, Debden and Heathrow Airport. When combined, the radar provided an almost complete record of the accident flight, with data starting just after G-CSFC had taken off from Hinton-in-the-Hedges Airfield and ending shortly before it landed at Leicester Airport. The period when G-CSFC and G-CLJK collided was recorded by several of the radars, with data points recorded at a maximum rate of once every five seconds.

Recorded information for G-CLJK was available from a combined electronic flight logger[3] and FLARM unit that was recovered from the cockpit. This provided a complete track log of the accident flight, with GPS-derived position, altitude and pressure altitude recorded once every four seconds.

A combination of radar, electronic flight logger and GPS-derived data from tablet computers[4] was also obtained for other aircraft operating in the vicinity of G-CSFC and G-CLJK at the time of the collision.

The RTF frequencies in use at Husbands Bosworth Airfield and Leicester Airport were not recorded. RTF recordings were available of communications between the D&D Cell and the pilot of G-BDIE.

Summary of recorded data

Figure 1 provides the radar and flight logger-derived tracks of G-CSFC and G-CLJK in the minutes before and after the collision. Figure 2 plots the position of both aircraft, commencing at a separation of just less than 1 nm, with the relative positions identified at eight second intervals and angular sizes of about 0.5° when viewed from each aircraft. Figure 3 plots the relative position of other aircraft at the time of the collision. For clarity, the radar track of G-CSFC has been illustrated in Figure 1, 2 and 3.

The track of G-CSFC recorded by each of the radars correlated closely, corroborating the relative accuracy of the independent data sources. The altitude amsl is derived by correcting for a QNH pressure of 1023 hPa.

When G-CLJK had taken off from Husbands Bosworth Airfield towed behind a tug aircraft, G-CSFC was 12 nm to the south. To the right of G-CSFC were two light aircraft, registration G-BPWG and G-BFLU, and behind G-CSFC was G-BOPA. All three aircraft were flying to Leicester Airport, having departed from different airfields in the south of England.

Footnote

2 Mode A refers to the four-digit 'squawk' code set on the transponder and Mode C refers to the aircraft's pressure altitude which is transmitted in 100 ft increments.
3 LX navigation manufactured FLARM Red Box.
4 Operating a Skydemon navigation software application.

At 1222 hrs, at an altitude of about 3,700 ft amsl, G-CLJK released from the tug aircraft and turned onto a northerly heading, whilst the tug turned away before landing back at Husbands Bosworth. G-CLJK continued on a northerly course whilst gradually descending at about 120 ft/min. G-CSFC was 7 nm to the south of G-CLJK at this time.

At 1225 hrs, G-CSFC altered course slightly, turning left onto a track between Husbands Bosworth Airfield and the town of Market Harborough. G-BPWG was at 3,100 ft amsl and now just ahead and to the right of G-CSFC at a distance of 1 nm, and G-BFLU was at 2,900 ft amsl and further ahead, at a distance of 1.3 nm.

At 1229 hrs, G-CSFC passed to the east of Husbands Bosworth Airfield; G-CLJK was 2nm ahead at 2,850 ft amsl. G-BPWG was maintaining its relative position to the right of G-CSFC and G-BFLU was now 2 nm ahead of G-CSFC.

At 1230 hrs, G-CLJK made a right turn onto a heading of about 220° (M); its altitude was 2,650 ft amsl and its groundspeed was about 44 kt. When G-CLJK had started to turn, G-ORBK was 0.8 nm away and maintaining a south-westerly course. G-CSFC was now 1 nm to the south of G-CLJK, and maintaining a northerly course at an altitude of about 2,600 ft amsl at a groundspeed of about 88 kt. Based on an estimated wind of 070° at 15 kt[5], G-CLJK would have appeared to have been approximately straight ahead when viewed from the cockpit of G-CSFC; similarly G-CSFC would have appeared to be about 15° to the left when viewed from the cockpit of G-CLJK.

Both aircraft maintained their relative tracks for a further 28 seconds, with G-CLJK gradually descending as the two aircraft converged; the calculated closing speed was 120 kt (61 m/s). The aircraft are estimated to have collided at 1230:47 hrs at an altitude of about 2,600 ft amsl (2,250 ft agl). The radar data indicates that G-CSFC started to turn to the left and descend at about this time. Table 1 contains the angular size[6] of each aircraft as they approached each other.

Footnote

5 Based on the weather reports recorded at Leicester Airport around the time of the accident.
6 This is based on the average of the span and height of the aircraft.

TIME TO COLLISION (s)	DISTANCE (nm) / (m)[7]	ANGULAR SIZE of G-CSFC when observed from G-CLJK (°)	ANGULAR SIZE of G-CLJK when observed from G-CSFC (°)
4	0.14 / 250	1.44	1.84
8	0.27 / 510	0.72	0.94
12	0.41 / 760	0.48	0.62
16	0.54 / 1,000	0.36	0.47
20	0.68 / 1,270	0.29	0.37
24	0.82 / 1,520	0.24	0.31
28	0.96 / 1,780	0.20	0.27
32	1.09 / 2,030	0.18	0.23

Table 1

Angular size of both aircraft from 32 seconds before the collision

The last data point from G-CLJK's flight logger was recorded at 1230:51 hrs, with the glider descending to 2,530 ft amsl at an average descent rate of 1,000 ft/min. G-CLJK subsequently struck the ground 290 m laterally from the position of the last data point.

Following the collision, G-CSFC descended to about 1,500 ft amsl, where it then levelled for several minutes before positioning to land at Leicester Airport, which was 7.5 nm north of where the aircraft collided.

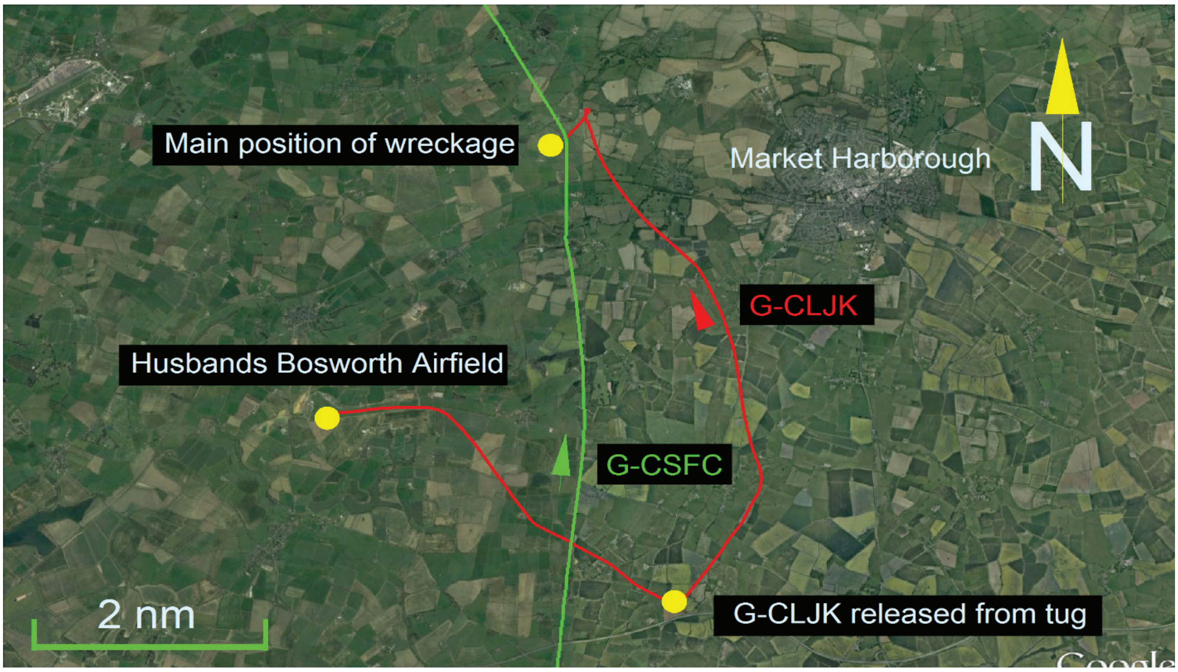

Figure 1

Radar and flight logger tracks of G-CSFC and G-CLJK

Footnote

7 Distances have been rounded.

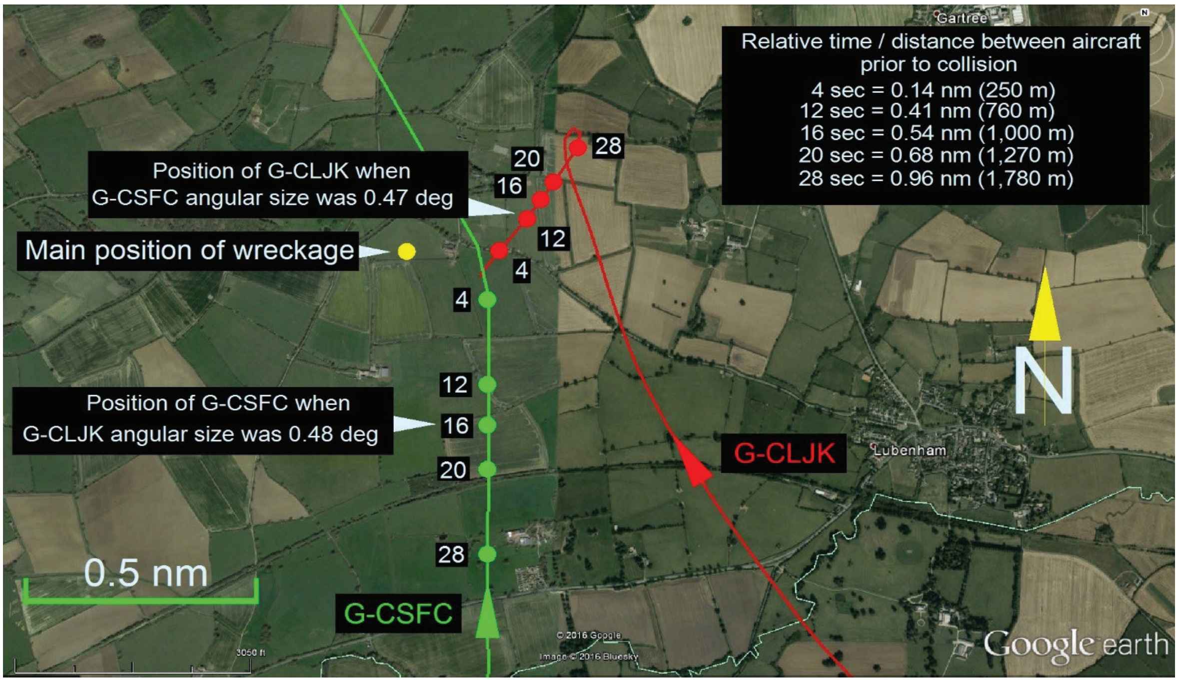

Figure 2

Relative positions of G-CSFC and G-CLJK prior to collision

Proximity of other aircraft at the time of the collision

- G-BFLU was ahead and to the left of G-CSFC at 2,500 ft amsl and a distance of 2 nm.
- G-BPWG was to the right of G-CSFC at 3,300 ft amsl, at a relative bearing of about 40° and a distance of 0.6 nm.
- G-ORBK was ahead and to the left of G-CSFC at about 2,600 ft amsl and a distance of 0.6 nm.
- G-BOPA was almost directly behind G-CSFC at about 1,400 ft amsl and at a distance of 0.4 nm.
- G-BDIE was 1.2 nm to the south of the accident position at 3,150 ft amsl.

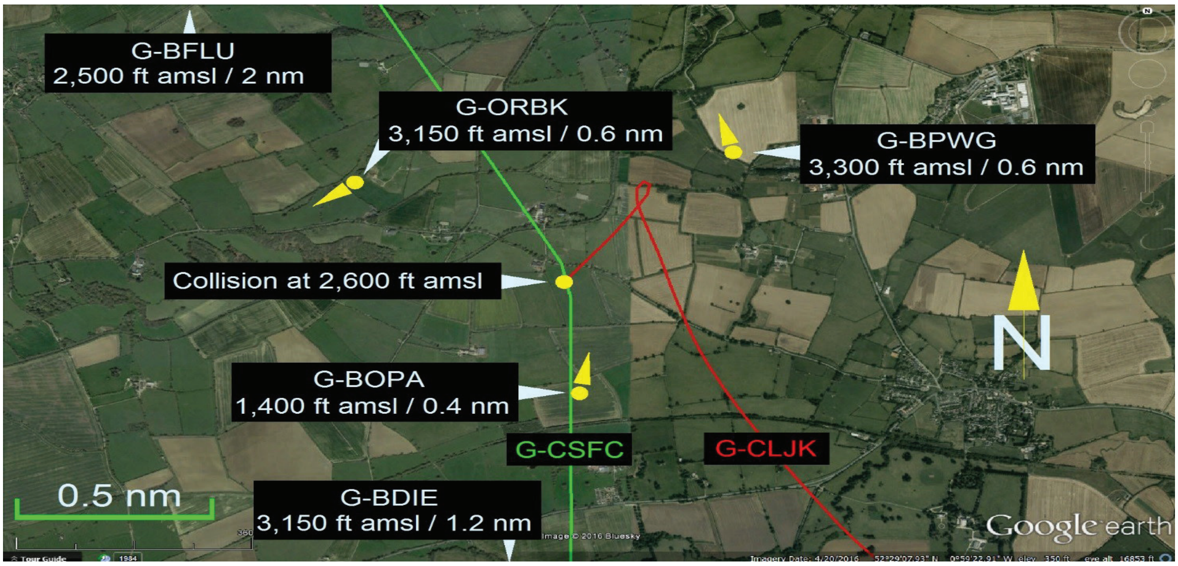

Figure 3

Relative positions of other aircraft at the time of collision

Meteorological information

There was an area of high pressure over the Continent, with a ridge of high pressure reaching out across the British Isles. This gave rise to settled and stable conditions, as reported by those flying on the day. Surface wind at the gliding club was reported as light, while at Coventry Airport (20 nm to the west) the surface wind at the time of the accident was from 070° at 12 kt, with good visibility and no low cloud. Analysis of the synoptic charts for the day indicated a wind at 2,000 ft from east-south-east at about 15 kt.

In-flight assessments were obtained from pilots who were flying powered aircraft and gliders in the area at, or near, the time. All reported good, stable flying conditions. Assessment of visibility was generally good, with reports ranging from "*a little hazy*" to "*fantastic*". However, all pilots commented on the low sun, and that visibility in the direction of the sun was reduced. One instructor of an aircraft (not involved in the events) remarked to his student that conditions were such that the risk of mid-air collision was increased.

Ephemeris sun data showed that, at the time of the accident, the sun was at an azimuth of 190° and an elevation angle of 15°. In this position, as seen from G-CLJK, the sun was in line with G-CSFC as the two aircraft approached each other during the 28 seconds prior to the collision.

Pilot information

G-CLJK

The pilot was an experienced glider pilot, who began gliding in 2005 and later qualified as a glider instructor. He regularly attended the gliding club at Husbands Bosworth, both to fly and to conduct ground instructional sessions. He owned an LS7 glider which he kept at Husbands Bosworth Airfield and had flown this since 2009. In the two months preceding the accident, he had started training to fly self-launching motor gliders (SLMG).

The pilot maintained good flying currency and generally flew on several days each month. He had last flown 5 days before the accident, when he flew two instructional flights and two SLMG flights. The pilot first flew the SZD-51-1 'Junior' glider in 2006 and had flown it occasionally since, with two flights recorded in 2016, with the most recent on 10 October 2016.

The pilot was believed to have been in good health and not suffering from any conditions which may have affected his ability to pilot his glider safely. He held a Light Aircraft Pilot Licence medical certificate which was issued by an Aeromedical Examiner[8] on 10 May 2016 and valid for two years. The certificate carried the limitation that the pilot was to wear corrective spectacles, which he was seen to be doing on the day of the accident. The

Footnote

[8] The examination for an LAPL medical certificate can be carried out by a NHS General Practitioner or by an Aeromedical Examiner (AME). An AME is a doctor specialising in aviation medicine who is certificated to issue EU medical certificates.

spectacles contained clear photochromic lenses, which darkened in response to exposure to UV radiation. The pilot with whom the accident pilot had flown that morning reported that the latter's vision in flight appeared normal and that he had detected other aircraft at reasonable ranges.

A post-mortem examination of the pilot of G-CLJK was carried out by a Home Office Registered Forensic Pathologist. He concluded that the pilot died as a result of multiple injuries consistent with having been caused when his aircraft struck the ground. There were no medical or toxicology factors that may have contributed to the accident.

G-CSFC

The instructor in command of G-CSFC began flying in 2008 and gained a Commercial Pilot's Licence in 2012. In April 2015 he trained at Leicester Airport as a flying instructor and subsequently started work as an instructor at the flying club based at Hinton-in-the-Hedges which operated G-CSFC. He flew regularly at the club and, on the day of the accident, flew an instructional flight before the accident flight.

The instructor held a Class One EASA medical certificate, valid until 4 May 2017 (4 May 2021 for Class Two privileges) and which carried the limitation that he wear corrective lenses. He reported that his normal glasses and his prescription sunglasses (which he was wearing on the accident flight) conformed to his current prescription. He appeared to have been in good health and did not declare any conditions which may have affected his ability to pilot the aircraft safely.

G-CLJK Aircraft information

The SZD-51-1 'Junior' is a single-seat glider with a wingspan of 15 m with a maximum all up mass of 380 kg. It was designed in Poland and is constructed predominantly of fibre glass. G-CLJK was white, except for the wing tips and part of the nose which were painted red.

G-CSFC Aircraft information

The Cessna 150 is a two-seat aircraft of conventional alloy construction and has a wing span of 10.2 m, and a gross weight of 726 kg. G-CSFC was painted white, with red and blue chordwise stripes just inboard of the wing tips, as well as along the fuselage sides.

The main G-CLJK wreckage site was located in a grass field approximately 8 m from a hedge and drainage ditch. This wreckage consisted of the fuselage, the empennage, the right wing and the inboard part of the left wing. There was a large ground mark in which several pieces of forward fuselage, canopy frame and Perspex from the canopy were located. There were straight ground marks either side of the hole which were consistent with having been made by at least part of both the left and right wings. Part of the canopy frame was located approximately 30 m from the main G-CLJK wreckage.

There were many pieces of wreckage located a significant distance from the main G-CLJK wreckage. These included:

- A 4.5m long outboard part of the left wing of G-CLJK, located 100 m from the main wreckage. There was a red scuff mark around the leading edge close to where it had broken away from the rest of the left wing of G-CLJK.
- The white plastic tip fairing (measuring approximately 20 cm in a spanwise direction) from G-CSFC found in several pieces.
- The outboard 40 cm of the right aileron from G-CSFC located in a tree 300 m from the main wreckage of G-CLJK.
- Two crumpled pieces of alloy wing with distinctive red and blue chordwise stripes; one piece was from the leading edge, the other was the mid-chord section aft of the leading edge and forward of the aileron. The deformation was most pronounced on the leading edge piece, particularly where the red chordwise stripe was located.

G-CSFC and G-CLJK inspection

G-CSFC was inspected at Leicester Airport (Figure 4). The outboard 60 cm of the right wingtip was missing and there was significant local damage to the outboard right wing.

Figure 4

Image of G-CSFC at Leicester Airport

Several pieces of wreckage that were recovered from the field near the glider, including the alloy section of wing leading edge and the piece of aileron, were taken to Leicester Airport and it was confirmed that they were from the outboard 60 cm of the right wing from G-CSFC.

Pieces from the right wingtip from G-CSFC were inspected in conjunction with the left outboard wing of G-CLJK at the AAIB. Both red and blue paint had been transferred onto a piece of the leading edge wing skin of G-CLJK, and the deformation to the alloy leading edge of a piece of G-CSFC right wingtip matched the profile of the left outboard wing leading edge of G-CSFC. It was tentatively concluded that that these were the locations where the two aircraft collided in a broadly head-on direction, with a relative bank angle of approximately 60°.

Glider abandonment

The glider was fitted with a four-point safety harness, comprising two lap straps and two shoulder straps and a safety strap. There was no negative 'g' (crotch) strap. The harness straps were secured centrally and held in place by a spring loaded locking bar which slid into place and was secured by a light spring arrangement. A short piece of webbing was attached to the bar which, when pulled, overcame the spring force and pulled the bar out, freeing the four straps almost simultaneously.

Only one other club glider was equipped with this locking arrangement, all others (and the pilot's own glider) used a rotary locking mechanism. Although the pilot had flown with G-CLJK's arrangement in the past, it was not one he was used to and prompted comment as he strapped in for the flight.

G-CLJK was fitted with a one piece canopy, which was side opening with two hinges on the right hand side. Its operation was controlled by two control levers and its range of movement on the ground was restricted by a wire lanyard. Both control levers were mounted on the canopy side rails and were similar in appearance. The left lever was for normal locking and unlocking of the canopy when closed; pushing the lever fully forward would unlock the canopy. The right lever, for emergency use only, operated a release mechanism for the two hinges. Moving the right lever fully forward released the two hinges from the fuselage, allowing the canopy to be jettisoned. There was a diagram placard next to the jettison handle which indicated its function.

The Pilot's Operating Handbook for G-CLJK contains the "Procedures for emergency exit" and "Procedures (for emergency exit) in special cases", Figure 6. The canopy is jettisoned by pushing forward on both the left and right red knobs and then pushing the canopy upwards.

5.3.1. Procedures for emergency exit

/1/ Let the stick free.

/2/ Push forward up to stop the handles of canopy jettisoning and push the canopy upwards.

/3/ Release the safety belts.

/4/ Leave the cockpit towards axis of eventual rotation of glider.

/5/ If the altitude allows delay the opening of parachute. On altitude below 200 m open the parachute immediately.

5.3.2. Procedures in special cases

/1/ When the canopy cannot be jettisoned try to destroy the perspex begining near the window, eventually help with legs.

/2/ In case the exit must be done on high altitude take into account:

a/ possibility of climbing on opened parachute /e.g.in cloud/ and the danger of lack of oxygen or iceing of parachute,

b/ possibility of employ the oxygen equipment installed on glider,

c/ air temperature.

Taking the above into account it may be recommended to stay inside the cockpit /if glider condition allows for/ to altitude of 4500 - 4000 m or even lower.

Figure 5

Extract from Pilot's Operating Handbook

The canopy of the pilot's own glider, an LS7, differed from the accident glider in that it was hinged at its forward end. It was also operated by two handles, one on each side rail, but they had slightly different functions and operated in the reverse sense to the accident glider. Both handles were used to lock and unlock the canopy, except they were moved rearward to unlock and forward to lock. If the right hand handle was pulled further rearwards than the normal unlocked position, the canopy hinge was released from its attachment to the fuselage, and the canopy could be jettisoned. Thus, to abandon the aircraft, both handles would need to be pulled fully back (the opposite of the accident glider), with the right handle travelling over a further distance than the left.

Canopy examination

The canopy frame was found at the accident site in six pieces, located within 30 m of the main wreckage along with a large number of pieces of Perspex. No Perspex pieces were found more than a few metres away from the main wreckage, and two of the pieces of canopy frame were embedded in the ground in close proximity to several pieces of the nose fuselage. It was concluded that the canopy struck the ground in close proximity to the fuselage.

The length of the canopy frame with the canopy release knob attached (left hand side) was assessed; the knob was found in the open position and could only be moved with some additional force being applied; this suggested that this knob was in the open position when the aircraft struck the ground.

The piece of the canopy frame which had the right hand jettison knob and the jettison mechanism (found 30 m from the fuselage) was assessed along with one of the canopy hinges. The canopy hinges are attached to the fuselage by two small vertical spigots; in each spigot there is a horizontal hole which houses the emergency jettison pin. Only one complete hinge was recovered from the wreckage site; the hole in the spigot was intact with no evidence of any impact marks from the jettison pin. The jettison mechanism on the canopy frame was intact, operated satisfactorily and was free from any impact marks that might have been caused by the spigot. There was therefore evidence that the canopy jettison mechanism had been successfully activated before the aircraft struck the ground.

Parachute and harness examination

The pilot was wearing a club parachute on the accident flight. He was familiar with the type of parachute, which was compatible with the cockpit and seat design. The parachute harness had two shoulder straps which were secured by a strap across the chest, and two crotch straps which passed forward between the legs and which were secured at each hip. The three fasteners were of a spring loaded 'snap hook' design.

The doctor and paramedics who attended in the air ambulance described their actions on arriving at the scene. The doctor recalled unclipping one or two metal fastenings but did not recall undoing anything which appeared to be an aircraft harness.
The aircraft harness was found undone. The harness was later inspected at the AAIB and found to operate satisfactorily.

Airspace operating information

Airspace classification

Airspace over the UK is divided into several classes, which are described in the UK Aeronautical Information Publication (UK AIP).[9]

The airspace in the accident area was designated as Class G airspace and was classified as uncontrolled. Aircraft operating in Class G airspace are free to operate without an ATC service or clearance, and pilots are not required to maintain contact with ATC or each other or operate with a transponder. Class G airspace includes all UK airspace which is not either controlled or advisory airspace.

Footnote

[9] The UK AIP is published by authority of the UK Civil Aviation Authority.

ATC instructions to pilots in Class G airspace are not mandatory. Although pilots may seek a Traffic service[10] from ATC, controllers cannot guarantee to achieve separation minima due to the nature of the unknown Class G air traffic environment.

The UK AIP states:

> *'Within Class G airspace, regardless of the service being provided, pilots are ultimately responsible for collision avoidance and terrain clearance, and they should consider service provision to be constrained by the unpredictable nature of this environment.'*

Rules of the Air

Both flights were subject to the Standardised European Rules of the Air (SERA)[11] regulations.

SERA.3210 Right-of-way stated:

> *When two aircraft are approaching head-on or approximately so and there is danger of collision, each shall alter its heading to the right.'*

SERA.2010 Responsibilities stated:

> *"The pilot-in-command of an aircraft shall, whether manipulating the controls or not, be responsible for the operation of the aircraft in accordance with this Regulation, except that the pilot-in-command may depart from these rules in circumstances that render such departure absolutely necessary in the interests of safety."*

SERA.3201 General stated:

> *'Nothing in this Regulation shall relieve the pilot-in-command of an aircraft from the responsibility of taking such action, including collision avoidance manoeuvres based on resolution advisories provided by ACAS equipment, as will best avert collision.'*

Footnote

[10] A Traffic Service is a surveillance based ATS in Class G airspace in which pilots are provided with a BasicService plus specific surveillance-derived traffic information to assist them to avoid other traffic. Terrain clearance and the avoidance of other traffic is solely the pilot's responsibility. The service is available to flights operating under VFR or IFR outside Controlled Airspace in any meteorological conditions.

[11] Commission Implementing Regulation (EU) No. 923/2012 of the European Parliament and of the Council of 26 September 2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation

Collision avoidance

In uncontrolled airspace, pilots operate on the principle of 'see-and-avoid'. Maintaining an effective lookout for aircraft and other hazards is therefore a prime task for a pilot to avoid collisions, particularly when flying in uncontrolled airspace. However, there are limitations in the human visual system that serve to make collision avoidance difficult by visual means alone.

The capacity of the human eye to resolve detail is not distributed evenly across the retina. The most central part of the retina is termed the fovea, and is composed only of cones - the light sensitive cells used for day vision. Cones provide high visual acuity, colour vision and contrast discrimination. Although there is good resolving power at the fovea, this ability drops rapidly only a few degrees away from it. Normal visual reflexes adjust the direction of gaze to ensure that the image of an observed object falls on the fovea for optimum resolution. Such vision, sometimes termed 'focal' vision, requires a stable image and the viewer's attention.

Away from the fovea, the density of cones reduces, and that of cells called rods increases. Rods are more sensitive to light than cones, and are used for day, night and low intensity vision. Rod vision is monochromatic and of low acuity, giving only outlines or shapes. It is, however, responsive to movement. It does not require the same degree of attention as focal vision and is important for spatial orientation and 'flow vision', which gives a sense of speed. Rod vision is sometimes referred to as 'peripheral' vision.

A distant aircraft will be perceptible to a pilot so long as it is acquired at or near the fovea. As an area of sky is scanned by the pilot, the eye naturally makes a series of jumps, or saccades, with intervening rests. The scene is only interrogated by the brain during the rest periods. A very small object may therefore be 'jumped over' or fall on an area away from the fovea – in either case it will not be detected. Each saccade-rest cycle takes a finite time and a full scan of an area of sky will take some seconds. An object missed early in the scan may have sufficient time to approach hazardously close or even collide before that area is scanned again by the pilot.

Two aircraft on a collision course maintain a constant relative bearing to each other and the aircraft will appear in the same place on the other aircraft's canopy unless the pilot makes a head movement. As the colliding aircraft is not moving relatively, it does not necessarily attract the attention of the peripheral vision system. The rate of increase in retinal size of the approaching aircraft is not linear and the image stays relatively small until very shortly before impact. Additionally, small targets may be hidden behind canopy arches or struts until very late. For these reasons pilots are taught not just to look around them, but to positively move their head as they do so.

Collision avoidance systems

The 'see-and-avoid' principle can be enhanced by the use of electronic conspicuity (EC) aids that enable the proximity of other airspace users to be known, with studies having shown that this can be eight times more effective[12].

There are several types of EC aid currently available, which include transponders and radios, but each has its own limitations and the use of different technologies has meant that not all systems are compatible.

G-CLJK was equipped with a type of EC aid called FLARM[13]. Many gliders in the UK are also equipped with this system, although the fitment of FLARM to powered aircraft across the UK general aviation[14] community is not as widespread. A limitation of the system is that only FLARM-equipped aircraft can detect each other. Further, it is not designed[15] to detect other aircraft equipped with a Mode A, C or S transponder or provide conspicuity to ground-based radar.

G-CSFC was fitted with a Mode C transponder that was transmitting data throughout the flight and its position and altitude was available on radar. It was not equipped with FLARM or other EC aid that would have alerted the pilots of G-CSFC to the position of G-CLJK.

The detection of G-CLJK's position was reliant on primary radar only, as it was not required, nor fitted, with a transponder. No identifiable radar track for G-CLJK was available[16].

In summary, although G-CSFC and G-CLJK were each equipped with a type of EC aid, the differing technologies meant that the pilots of both aircraft were reliant on visually acquiring each other's aircraft in order to take avoiding action.

Future development of EC aids.

Several Safety Recommendations have been made by the AAIB to improve the conspicuity of aircraft operating in uncontrolled airspace. Following mid-air collisions involving two gliders in April 2004, and a helicopter and microlight aircraft in July 2004, the AAIB issued Safety Recommendation 2005-006 to the CAA to initiate further studies into improving conspicuity of gliders and light aircraft. In 2005, the UK Airprox Board also recommended

Footnote

[12] Unalerted Air-to-Air visual Acquisition Andrews MIT 1991 Project Report ATC-152

[13] FLARM was invented in Switzerland in 2004 in response to a high number of fatal mid-air collisions between gliders, which despite the principle of 'see and avoid', were still occurring in good visibility. FLARM is a flight alarm system that transmits the position and altitude of an aircraft over a low-powered, short-range radio to other FLARM-equipped aircraft once every second. The system is capable of displaying the proximity of other FLARM-equipped aircraft to pilots and providing an audible and visual warning if there is a risk of collision.

[14] Civil aviation operations other than scheduled air services and non-scheduled air transport operations for remuneration or hire.

[15] Power FLARM is a recent development of the original FLARM technology. This includes the ability to detect Mode C, Mode S and ADS-B transmissions.

[16] Gliders have a relatively low radar cross-section and are typically constructed from composite materials, which reduces the likelihood of them being detected by primary radar.

that the CAA should promote the production, and subsequently mandate the use of a 'lightweight' transponder for gliders. In response, the CAA considered Mode S transponders to be the most appropriate equipment, but following consultation with the general aviation community, decided that it was not appropriate to mandate their use for operations in uncontrolled airspace.

The principal arguments against the mandatory fitment of a Mode S transponder was their relatively high power consumption, weight and cost. Moreover, if neither conflicting aircraft was in receipt of an ATC radar service, then no alert could be given to the pilots.

In 2010, following the collision between a glider and light aircraft[17], the AAIB recommended that the CAA, in light of technological changes, review again the EC of gliders and light aircraft operating in uncontrolled airspace. In 2014, an Electronic Conspicuity Working Group (ECWG) was established by the CAA, working collaboratively with NATS[18] and associations from across the general aviation community. Several manufacturers also participated, with project funding provided by the Department for Transport.

The main aim of the ECWG was to provide a technical specification for EC devices suitable for aircraft, gliders and balloons operating in uncontrolled airspace, and assurance that such devices will not compromise the performance of current air-to-air or air-to-ground safety systems already in operation, such as TCAS and ground-based radars. As part of this work, NATS conducted a trial, known as project 'EVA[19]' which ran between August 2014 and October 2016, working with AOPA[20], Trig Avionics and f.u.n.k.e Avionics. This looked at establishing the suitability of a non-certified GPS device performance when used with Automatic Dependent Surveillance-Broadcast (ADS-B)-based collision avoidance systems.

In December 2016, the CAA published the results of the project in CAP 1391, with the specified device incorporating similar functionality to FLARM, but based on ADS-B technology.

In July 2015, the ECWG merged with the Visual and Electronic Conspicuity Working Group to form the Conspicuity Working Group (CWG). The CWG forms part of the CAA's Mid-Air Collision (MAC) Programme, with the task of promoting the development of EC's and their voluntary[21] carriage on aircraft, gliders and balloons operating in uncontrolled airspace. The CAA website[22] includes details of EC devices that meet the specification in CAP 1391.

Footnote

[17] AAIB report 5/2010, aircraft G-BYXR and glider G-CKHT
[18] NATS is the UK national ATS provider.
[19] http://www.nats.aero/projecteva/
[20] AOPA - Aircraft Owners and Pilots Association, http://www.aopa.co.uk/
[21] CAP 1391 states "it is not mandatory for GA aircraft in Class G airspace to have an EC device and there is no appetite, either within the ECWG or among stakeholders, to change that. Instead, the goal is to create an environment which encourages more pilots to voluntarily equip their aircraft with an EC device."
[22] http://www.caa.co.uk/General-aviation/Aircraft-ownership-and-maintenance/Electronic-Conspicuity-devices/

Performance of FLARM fitted to G-CLJK

Analysis of FLARM data gathered from ground stations[23], G-CLJK and other aircraft in the vicinity indicated that the FLARM system fitted to G-CLJK had a reduced operating range of about 1 km, compared to an expected range of 3 km to 5 km. The evidence indicates that the lower than expected range of the FLARM fitted to G-CLJK was most likely due to a non-optimised antenna installation, rather than a fault within the system.

FLARM uses two antenna, one for GPS reception and one radio frequency (RF) antenna that transmits and receives information from other FLARM-equipped aircraft. FLARM states in its installation guide for the RF antenna, "*the correct installation has a considerable effect upon range for transmitter/receiver range, so the installation must be carefully considered*".

The manufacturer of the FLARM unit fitted to G-CLJK provided a 'user' manual, which included guidance on how to install and use the system. The manufacturer did not provide guidance on how to test the performance of the system following its fitment. The FLARM system incorporates its own built-in-test function that can alert the pilot of internal faults within the unit, but it cannot determine nor display its operating range.

FLARM also provides information for units that it manufactures. This includes a 'range analyser' software tool that is provided on its website[24]. Using this software tool, the range of the system, and corresponding 'quality' of the antenna installation, may be measured by analysing recorded data.

The reduced performance of the FLARM fitted to G-CLJK was not a factor in preventing this accident, but it is important that efforts are made to ensure that EC systems operate as expected, such that the maximum safety benefit may be obtained where possible.

The AAIB discussed with FLARM, and the manufacturer of the system fitted to G-CLJK, that improved guidance of antenna installations and awareness of how to test the performance of FLARM would be beneficial.

Safety action taken

- FLARM has published guidance information on post-installation testing of its systems, which has also included guidance on the installation of antenna. This can be found on the manufacturer's website[25].

- The manufacturer of the FLARM system fitted to G-CLJK has published guidance information on post-installation testing of its system. This can be found on the manufacturer's websites[26].

[23] The Open Glider Network (OGN) - http://wiki.glidernet.org/ - which provides an online service for tracking FLARM equipped aircraft.
[24] http://flarm.com/support/tools-software/flarm-range-analyzer/
[25] http://flarm.com/support/manuals-documents/
[26] http://www.lxnavigation.com/support/manuals/

- The British Gliding Association (BGA) published information in its January 2017 Newsletter to raise awareness of the ability to check the range of FLARM systems.
- The BGA also referred to information already available on its website relating to conspicuity devices.

BFU airprox and collision study

The German Federal Bureau of Aircraft Accident Investigation (BFU) published in January 2017 a "Study Concerning Airproxes and Collisions of Aircraft in German Air Space 2010 – 2015. In section 2.3 the report notes the difficulty in detecting gliders early. It also notes the US Navy studies in which the estimated reaction time from the moment of recognition to the avoidance manoeuvre is around 12½ seconds.

Previous mid-air collisions

The CAA database was interrogated for records of mid-air collisions that had occurred within the UK in the 10 year period prior to, and not including, this accident. Military aircraft and balloons were excluded. Over this period, there were 22 mid-air collisions, resulting in 17 fatalities. There were 11 mid-air collisions that involved at least one glider, but only one of these resulted in a fatality to the glider pilot

Analysis

General & pre-collision

Both the commander of G-CSFC and the pilot of G-CLJK were appropriately qualified and experienced to conduct their respective flights. Both were wearing their required glasses.

The accident occurred in uncontrolled Class G airspace in which both aircraft were entitled to fly. The pilots of G-CSFC had been in receipt of a basic service until shortly before the accident. As G-CLJK was not fitted with a transponder there would not have been an identifiable radar track displayed to the controller and ATC would not have been able to provide a warning to G-CSFC. The radio fitted to G-CLJK was not receiving, and therefore the pilot would not have been able to listen out for traffic movements. Further, although both aircraft were fitted with a type of EC aid, FLARM in G-CLJK and a transponder in G-CSFC, the differing technologies meant that they did not communicate with each other. Therefore the pilots of G-CSFC and pilot of G-CLJK were reliant on visually acquiring each other's aircraft in order to avoid a collision.

There were several other aircraft in the area and these were a source of distraction for the pilots of G-CSFC, and these were also likely to have been a distraction for the pilot of G-CLJK. The right hand turn made by G-CLJK may well have been in response to seeing the helicopter G-ORBK approaching from the right, in which case it is possible that the pilot's attention may have been focused on the helicopter after having completed the turn. Following the turn, the view of the pilot of G-CLJK in the direction of G-CSFC would have been impaired by the glare from the sun, which was directly in line with G-CSFC for approximately 20 seconds prior to the collision. The lack of any apparent avoiding action by the pilot of G-CLJK suggests that he saw G-CSFC very late, if at all. The sun was not a factor for G-CSFC crew.

The avoidance of collision manoeuvres presupposes that pilots have established visual contact in time to take avoiding action. In this situation, the avoiding manoeuvre of G-CSFC was consistent with the provisions of SERA which allow a pilot to depart from the rules in the interests of safety.

Post-collision

The spinning and/or tumbling motion of G-CLJK described by the witnesses was consistent with a loss of control resulting from the extensive damage to the left wing.

It was not possible to determine accurately the time available for the pilot of G-CLJK to abandon the glider. The time between the collision at 2,250 ft agl and G-CLJK striking the ground was likely to have been between 10 and 30 seconds (assuming an estimated vertical speed of between 150 and 50 mph respectively). This gave limited time for the pilot to first assess the situation, jettison the canopy, release the harness and make a successful abandonment.

There was evidence that the pilot of G-CLJK made the correct actions to enable the canopy to be jettisoned, although at what stage in the descent could not be determined. The wreckage of the canopy was in close proximity to the fuselage wreckage and therefore it is not clear if the pilot was having difficulties jettisoning the canopy. Post-collision the environment within the glider is likely to have been disorientating and physically limiting due to the forces, which would have reduced the chance of a successful abandonment in the limited time and height available.

Conclusions

The accident occurred because the pilots did not see each other's aircraft in sufficient time to take effective avoiding action. Collision avoidance was by lookout and visual detection, which has limitations, and the low sun would have reduced the likelihood of the pilot of G-CLJK seeing G-CSFC in time.

G-CLJK was fitted with FLARM but G-CSFC was not fitted with such a system. Therefore, there was no electronic means to increase the ability to detect other aircraft in the vicinity to allow for effective collision avoidance. The CAA have since issued CAP 1391 and are part of CWG which promotes the installation of EC devices in aircraft.