ACCIDENT

Aircraft Type and Registration:	1) Vans RV-6A, G-RVGC 2) DA 40D Diamond Star, G-CEZR
No & Type of Engines:	1) 1 Lycoming 0-320-D3G (Modified) piston engine 2) 1 Thielert TAE 125-02-99 piston engine
Year of Manufacture:	1) 2004 2) 2008
Date & Time (UTC):	4 July 2011 at 1528 hrs
Location:	Shoreham Airport, West Sussex
Type of Flight:	1) Post-modification test flight 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 - None Passengers - N/A
Nature of Damage:	1) Destroyed 2) Propeller and gearbox detached, damage to left wing
Commander's Licence:	1) Private Pilot's Licence 2) Airline Transport Pilot's Licence
Commander's Age:	1) 62 years 2) 60 years
Commander's Flying Experience:	1) about 20,600 hours (of which n/k were on type) Last 90 days - n/k hours Last 28 days - n/k hours 2) 3,450 hours (of which 32 were on type) Last 90 days - 35 hours Last 28 days - 13 hours
Information Source:	AAIB Field Investigation

Synopsis

Two aircraft collided, in good weather, in the visual circuit. G-CEZR was rejoining the circuit on the crosswind leg and G-RVGC was on the downwind leg. G-RVGC was rendered uncontrollable by the collision and the pilot was fatally injured when the aircraft struck the ground. G-CEZR, though damaged, was able to land without further damage or injury.

Background G-RVGC

G-RVGC (GC) was on its third flight following an extended period in maintenance, undergoing major modification. The pilot, who was a friend of the owner, had been asked to carry out the test flying required for approval of the modifications, prior to the aircraft undergoing a check flight for renewal of its Permit to Fly. The pilot arrived at the maintenance organisation's hangar at about 0830 hrs and spent between 60 and 90 minutes inspecting the aircraft and familiarising himself with its new avionics fit, which included an Electronic Flight Information System (EFIS) display. Two flights of 19 and 23 minutes, respectively, were then completed with no major defects reported. A minor oil weep was rectified between these flights and the manifold pressure gauge was found to be unserviceable. This was traced to a faulty sensor and the pilot accepted the aircraft without this gauge functioning.

Background G-CEZR

G-CEZR (ZR) was operated by a Shoreham based flying school. One of the flying school's instructors was in the process of upgrading his instructor qualifications and the objective of the flight was for him to practise teaching instrument flying to another instructor.

To facilitate the training, the aircraft commander sat in the left seat, acting as a student. The trainee instructor sat in the right seat, practising his instructional technique. No instrument flying screens or 'foggles' (goggles modified to simulate instrument flying conditions) were in use. At the time of the accident the lesson was complete and the aircraft was making a visual return to Shoreham. The pilot in the right seat was pilot flying (PF) and making the radio calls.

History of the flights

GC departed from Shoreham on its third flight at 1433 hrs and the majority of the flight was recorded by radar (see Figure 1). The pilot called Shoreham ATC for rejoin from the Washington intersection Visual Reporting Point (VRP) at 1519:10 hrs. He was offered a direct arrival, to right base, for Runway 20 but he requested a crosswind join for circuits, saying that he needed to "DO SOME HOURS ON THIS".

ZR departed Shoreham at 1430 hrs and operated, initially, in the instrument pattern overhead the airfield, before departing to the west to conduct general handling exercises. ZR's flight was also recorded on radar (see Figure 1). At 1522:20 hrs the PF reported at the Littlehampton VRP and requested a crosswind join for Runway 20.

Shoreham ATC was operating a single radio frequency with one ATCO operating as both the Approach Controller and Tower Controller.

At 1522:30 hrs the Shoreham ATCO told ZR to report north abeam Worthing Pier (see Figure 2) and "LOOK OUT FOR AN R V SIX JOINING LIKEWISE". GC had already crossed the upwind end of Runway 20 and, immediately after ZR acknowledged the ATCO's instruction, GC reported "G-GC WE'VE JUST JOINED ER CROSSWIND JUST ABOUT TO TURN DOWNWIND". The ATCO acknowledged this call and asked GC to report downwind, which the pilot did at 1523 hrs. He was then told that he was number two to a helicopter on long final and to report on final approach.

At 1524:30 hrs GC reported on final approach for a touch-and-go, with the helicopter in sight, and was told to continue the approach before, at 1524:50 hrs, being cleared for the touch-and-go. Another aircraft, G-TLET (G-ET), a Piper PA-28, was then cleared "AFTER THE R V SIX ON FINAL LINE UP TWO ZERO". At 1525:10 hrs ZR reported north abeam Worthing Pier and was instructed to report crosswind. The ATCO advised the crew that there were "TWO IN THE CIRCUIT".[1]

At 1526 hrs G-ET was cleared to take off, with a left turn out. The radio frequency was then occupied for

Footnote

[1] G-RVGC (GC) was on final approach and G-WARZ (G-RZ), a Piper PA-28, was on the downwind leg.

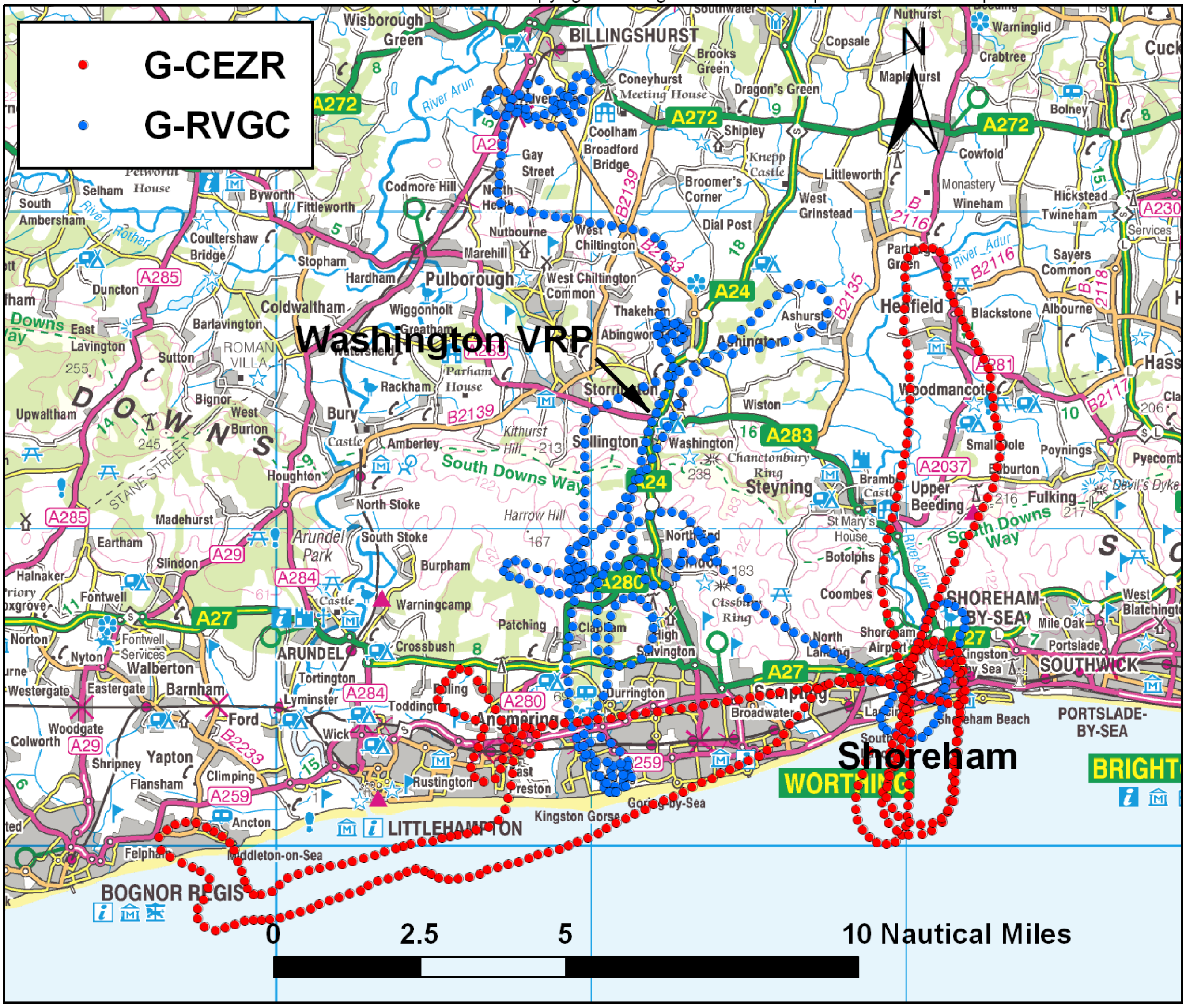


Figure 1

Radar tracks of G-CEZR and G-RVGC from 1444 hrs to the collision at 1527:18 hrs

50 seconds by two other aircraft (G-HD and G-OS) asking for, and one receiving, joining instructions. At 1526:50 hrs ZR reported crosswind. This was acknowledged by the ATCO who instructed ZR to report turning downwind. The ATCO did not see ZR as it approached the airfield. Based on the first circuit flown by GC, the ATCO believed that it would be ahead of ZR and was expecting it to be near the downwind position when ZR crossed over the upwind end of Runway 20.

ZR was still on the crosswind leg when there was a "huge bang" and the aircraft rolled to the left by a substantial amount. To confirm who was handling the aircraft, the PF called "I have control" and recovered the aircraft to a glide attitude, turning left downwind. He assessed the damage and realised that the propeller was missing and that there was a hole in the leading edge of the left wing. Although he needed to use considerable right rudder to maintain control, the PF was able to land ZR on non-active Runway 25, with no further damage.

While the PF flew the glide circuit, the instructor saw GC make a wide descending left-hand spiral into open ground near the airfield. Neither pilot had seen GC before the collision.

The ATCO had continued to issue joining instructions to the previous request, before, at 1527:25 hrs, G-RZ reported on final approach for a touch-and-go. As the ATCO cleared this aircraft for its touch-and-go, a radio transmission was heard saying "MAYDAY MAYDAY". The transmission was partially garbled by other simultaneous transmissions and the callsign was unintelligible. The ATCO replied "STATION TRANSMITTING MAYDAY SAY AGAIN". "MAYDAY MAYDAY" was repeated. However, again the transmission was garbled, with the station identity and message being blocked. At 1527:40 hrs the ATCO again requested "STATION TRANSMITTING MAYDAY SAY AGAIN". Another aircraft then reported that "HE'S GONE IN BEHIND THE AIRFIELD BEHIND".

Eyewitnesses, including an off-duty police officer, ran to the scene of the accident. A large fire had developed and its intensity prevented them from approaching GC. The Airport Fire and Rescue Service and West Sussex Fire Service also attended the site and the fire was extinguished about 10 minutes after the accident had happened. The pilot's body was found in the aircraft wreckage. He had been fatally injured.

Figure 2 shows the radar tracks, starting at 1524:55 hrs, with ZR approaching Worthing pier and GC on final approach, as it was cleared for a touch-and-go, before it briefly descended below radar coverage. The figure also includes all relevant radio transmissions.

G-CEZR

The pilots of ZR had been alerted to other circuit traffic by the ATCO's radio call of "TWO IN THE CIRCUIT" when they had just passed Worthing Pier. When interviewed on the evening of the accident the PF could recall that, as they approached the airfield, there was an aircraft on base leg, an aircraft which had just touched down and a third aircraft was calling for rejoin. The instructor could not recall any radio messages that led him to believe there were any aircraft that would be in their proximity.

When interviewed later, with the aid of the radio recordings, the crew of ZR were able to place the other aircraft in their approximate circuit positions. The PF recalled that, as they approached the airfield, he had seen an aircraft on the runway and, based on his expectations of its flightpath, believed that there would be no confliction. The PF commented that, throughout the flight, he was maintaining his normal lookout, which he described as a sine wave pattern above and below the horizon with a series of short stops to allow his eyes to focus. On the crosswind leg he saw no traffic to his right.

At the second interview the instructor could place one aircraft on the runway and another about to line up but considered there should have been no conflict with them. The instructor stated that he would not rely on ATC for traffic alerting and that circuit traffic could come from "all over the place". When they were approaching the downwind leg he was looking to the right for traffic coming up from the runway, though he was not expecting anything that might be in close proximity to them.

Witnesses

Various witnesses on the ground saw the collision and aftermath. Before the collision, there was no evidence of any avoiding action by either aircraft. Following the collision, GC appeared to the ground witnesses to have lost its fin and rudder and to have sustained damage to

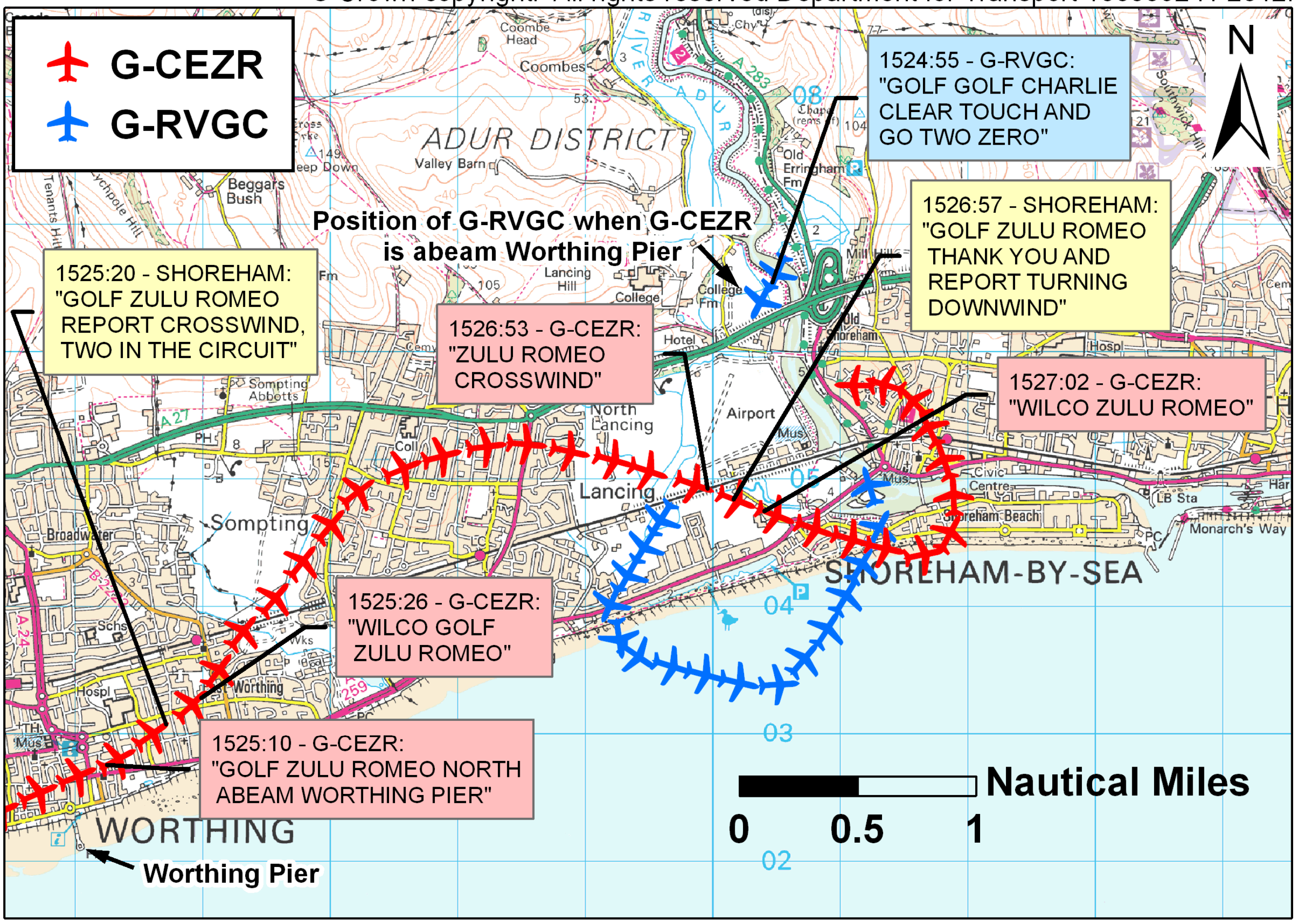


Figure 2

Radar tracks of G-CEZR and G-RVGC from 1524:55 hrs, with relevant radio calls

one or both horizontal stabilisers and elevators. It was described as, initially, descending towards the River Adur before changing course slightly to crash into an open area at the Adur recreation ground.

Recorded Data

Both aircraft were equipped with a GPS unit. ZR's GPS unit did not include the memory card necessary for recording flight logs and the unit recovered from the wreckage of GC had been destroyed by the post-impact fire, rendering any recorded data irrecoverable. Both aircraft were, however, fitted with Mode S transponders, enabling the radar head at Pease Pottage, about 15 nm to the north of Shoreham, to record their position and altitude every six seconds. The transponder fitted to GC had a basic setup which only broadcast altitudes with 100 ft resolution (ie ±50 ft), together with groundspeed and track angle. The transponder fitted to ZR gave altitudes with 25 ft resolution (ie ±12.5 ft), as well as groundspeed, airspeed, roll attitude, track and heading.

Figure 3 shows a close up of the radar tracks at Shoreham and details the relative positions of the aircraft leading up to the collision.

The figure shows that as ZR was about 1 nm from the airfield, on a track to pass over the upwind end of

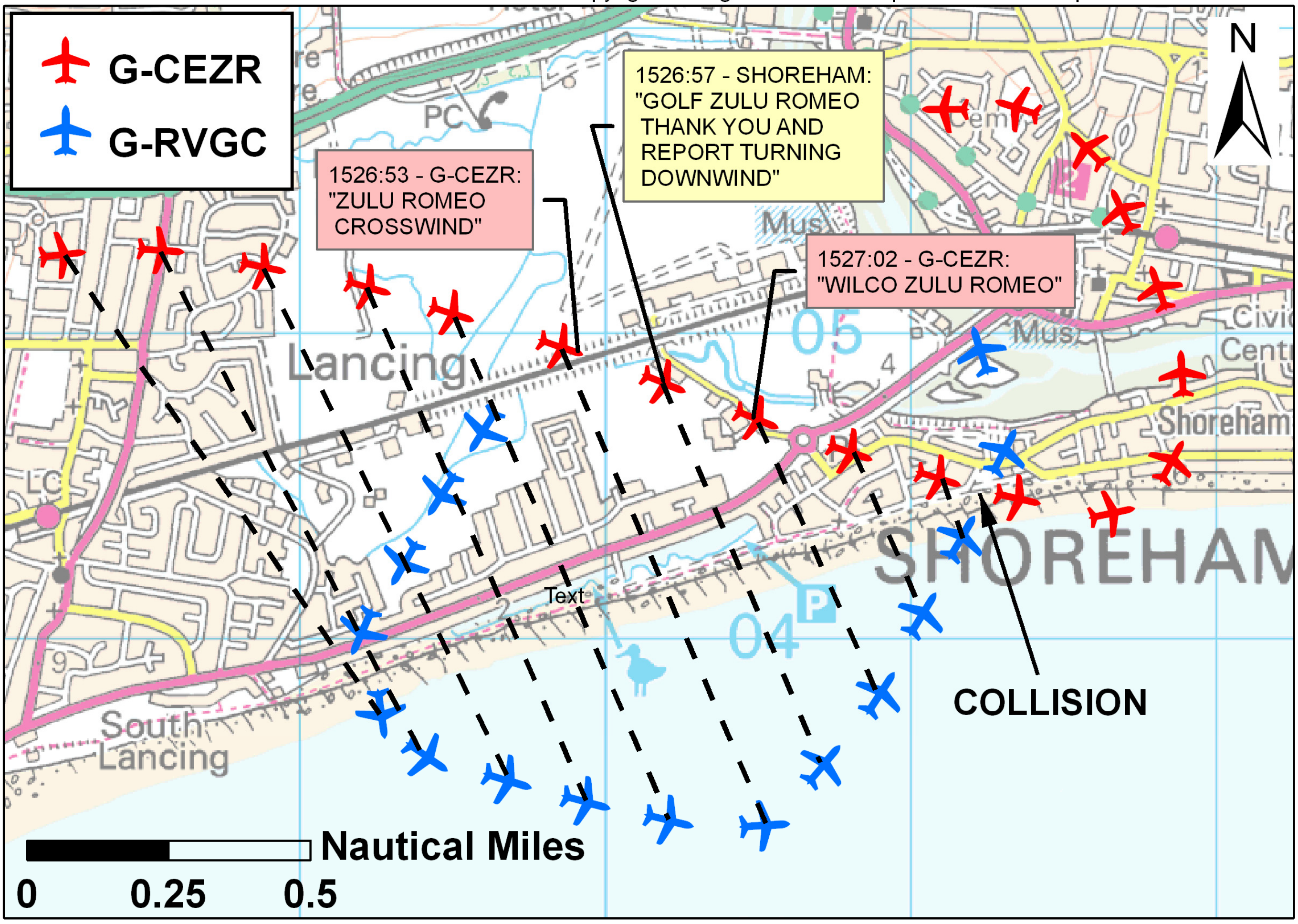


Figure 3

Close up of radar tracks with G-CEZR joining, and G-RVGC, in the circuit, through to the collision

Runway 20, GC was turning onto the crosswind leg of the circuit. ZR was descending through 1,225 ft (±12.5 ft) aal and GC was climbing through 800 ft (±50 ft) aal, with a groundspeed of about 90 kt. As ZR crossed over the upwind end of Runway 20 it levelled off at 1,075 ft (±12.5 ft) aal, where it remained until the collision. GC climbed through 1,100 ft (±50 ft) aal as it turned onto the downwind leg, levelling off briefly at 1,200 ft (±50 ft) aal before descending. At 1527:16 hrs, about 3 seconds before the collision, ZR was at 1,075 ft (±12.5 ft) aal and GC was at 1100 ft (±50 ft) aal; the groundspeed for each aircraft was about 96 kt and 94 kt respectively. Figure 3 also shows that, from the perspective of the ZR cockpit, GC was on an approximately constant bearing from the time it turned onto the crosswind leg until the collision.

Pilot information

G-RVGC

The pilot had worked as an airline pilot on UK registered large commercial passenger jet aircraft. He owned an RV-6, equipped with EFIS, and had considerable light aircraft flying experience. Although his latest logbook was destroyed in the accident, a logbook, starting in August 2002 and ending in July 2010, showed that he ceased airline flying during 2003, with a total of

20,120 hrs. He continued to fly light aircraft and in May 2010 had accrued a total of 20,540 hrs. This was a rate of some 60 flying hours per year and there was anecdotal evidence that he had continued flying at a similar rate in the period between the end of the complete logbook and the accident. The pilot's JAR Private Pilot's Licence (Aeroplanes) was issued in December 2009, on the expiry of his Airline Transport Pilot's Licence. He held a Single Engine Piston (SEP) rating.

G-CEZR

Commander

The commander had held a flying instructor rating for over 30 years. At the time of the accident he was qualified to instruct on single and multi-engine aircraft, as well as to train instructors to teach instrument and multi-engine flying.

Trainee instructor

The trainee instructor held a Commercial Pilot's Licence with a flying instructor's rating. He had qualified as a flying instructor in 2008, had 1,200 hrs and was in the process of upgrading his instructor's rating to allow him to teach instrument flying.

Meteorology

The weather observation at Shoreham Airport at 1541 hrs reported a surface wind from 160° at 4 kt, greater than 10 km visibility and no low cloud. The sun was to the south-west at an angle of about 55° above the horizon. Other pilots were able to provide additional weather information for the time of the accident; they reported no cloud and estimated the visibility at over 30 nm.

Medical information

G-RVGC

A specialist aviation pathologist conducted a post-mortem examination and reported that the pilot had died of head and chest injuries, the cause of which was consistent with the aircraft striking the surface of the ground. There was no evidence to suggest that the pilot was alive during the subsequent fire. The pathologist also reported that there was no evidence of drugs or alcohol having been consumed or natural disease which could have had any bearing on the accident. The pilot held a valid JAA Class 2 medical certificate.

G-CEZR

Neither pilot reported any medical condition, or level of fatigue, likely to have affected the operation. Following the accident, both were breathalysed by the police and the results were negative. Both pilots held valid JAA Class 1 medical certificates.

Aircraft information

G-RVGC

The RV-6A is a two-seat, side-by-side, low-wing monoplane with tricycle landing gear. Constructed from a kit and primarily of aluminium, GC was predominantly coloured white with a dark blue lower fuselage. It was equipped with avionics featuring Advanced Flight Systems Inc EFIS displays. The displays can be integrated with traffic alerting systems; however, GC was not equipped with a compatible system. GC was operating under an LAA Permit Flight Release Certificate to allow the aircraft to be test-flown following installation of an autopilot, new avionics and a propeller overhaul. The permit was valid between 17 June and 17 July 2011. The permit-to-test named the accident pilot as the approved pilot for this test flying.

G-CEZR

The DA-40D is a four-seat, low-wing monoplane with tricycle landing gear. It is primarily constructed of composite materials and, therefore, is mainly coloured white. ZR was equipped with Garmin G1000 avionics. A traffic alerting system, which detects Mode S transponder signals, was available as an option but was not fitted.

Examination of both aircraft

G-RVGC

The wreckage of GC was examined on-site on the afternoon of the accident. Much of the aircraft had been consumed by an intense ground fire and lay in the Adur Recreation Ground, some 100 metres south of the airfield boundary. A series of ground marks and a trail of wreckage showed that the aircraft had struck the ground, some 70 metres east of the main wreckage, in a left-wing-low and 45° nose-down attitude, at high speed. Two propeller slash marks were found in the ground and this evidence, together with the degree of disruption to the wooden propeller blades, indicated that the propeller was turning under moderate to high power.

After the heaviest impact mark, caused by the engine, the aircraft appeared to have performed a 'cartwheel' before coming to rest with the rear fuselage and tailplane resting on top of the inverted right wing, with the engine only partially attached. It was immediately evident that the vertical fin and rudder were not present at the site and closer examination showed that the tip of the left tailplane and elevator (including its mass balance) were also missing. An impact had also separated the left elevator into two halves, although both sections had remained loosely attached until after ground impact.

G-CEZR

The aircraft had been towed to the Police Air Support Unit's secure hangar before the AAIB examination. It was immediately apparent that the propeller was missing, as a result of fracturing in the reduction gearbox which connected it to the engine. There was a 90 cm section of the left wing composite leading edge missing, at about mid-span, (Figure 4) and a piece of the fin structure from GC was lodged in the left aileron control horn. There was other minor damage to the aileron and flap on the left wing, and the nosewheel. Apart from these, there appeared to be no further damage to ZR.

Debris field

Pieces of both aircraft were located some distance from the main wreckage, the furthest debris lying about 1.25 km southeast, on Shoreham Beach. This comprised ZR's wooden propeller attached to a section of the reduction gear casing, minus the majority of the two shattered blades. Some composite parts of the leading edge of ZR's left wing were also recovered. In addition, in this debris field were the fin and rudder from GC, its left tailplane and elevator tip and its inboard elevator hinge.

ATC

The ATCO, who had been qualified at Shoreham for over 12 years, commenced duty at 0830 hrs and followed a rotating work cycle of two hours on operational duty followed by a one hour break. The ATCO had been on operational duty for 58 minutes prior to the accident, acting in support of the other off-going operational ATCO. At 1521 hrs, the ATCO took over the operational position, providing a combined Aerodrome (ADC) and Approach Procedural (APP) service, without the aid of surveillance equipment. At interview, the ATCO indicated being "comfortable" with the workload.

Figure 4

Leading edge damage to G-CEZR

Shoreham ATC operated an abbreviated flight progress strip system, using acrylic flight progress 'chips' for all local and visiting aircraft. Flight progress strips were used, as required, to provide more specific flight information for local flights of a more complex nature.

The construction of the Visual Control Room (VCR), and the level of its roofline, limits the ATCO's view of traffic joining overhead. The ADC position affords a good view of aircraft joining crosswind for Runway 20 at a circuit height of 1,100ft.

ATC procedures

An Aerodrome Traffic Zone (ATZ) has the characteristics of the airspace in which it is located. The Shoreham ATZ is located within an area of Class G uncontrolled airspace. Therefore, ATC are not required to provide separation between VFR traffic.

The *Manual of Air Traffic Services* Part 1 (MATS 1), Section 2 defines the responsibilities of the Aerodrome ATCO as:

> *'2.1 Aerodrome Control is responsible for issuing information and instructions to aircraft under its control to achieve a safe, orderly and expeditious flow of air traffic and to assist pilots in preventing collisions between: a) aircraft flying in, and in the vicinity of, the ATZ;'*

Responsibility for collision avoidance, therefore, rests with the pilot(s) in command.

Rules of the air

Civil Aviation Publication (CAP) 393, *Air Navigation: The Order and the Regulations, Section 2, The Rules of the Air Regulations 2007* states in *Section 4, General Flight Rules*:

'Avoiding aerial collisions

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

(5) Subject to sub-paragraph (7), an aircraft which has the right-of-way under this rule shall maintain its course and speed.

Converging

9 (3) Subject to paragraphs (1) and (2), 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.'

Standard civil aerodrome circuit pattern

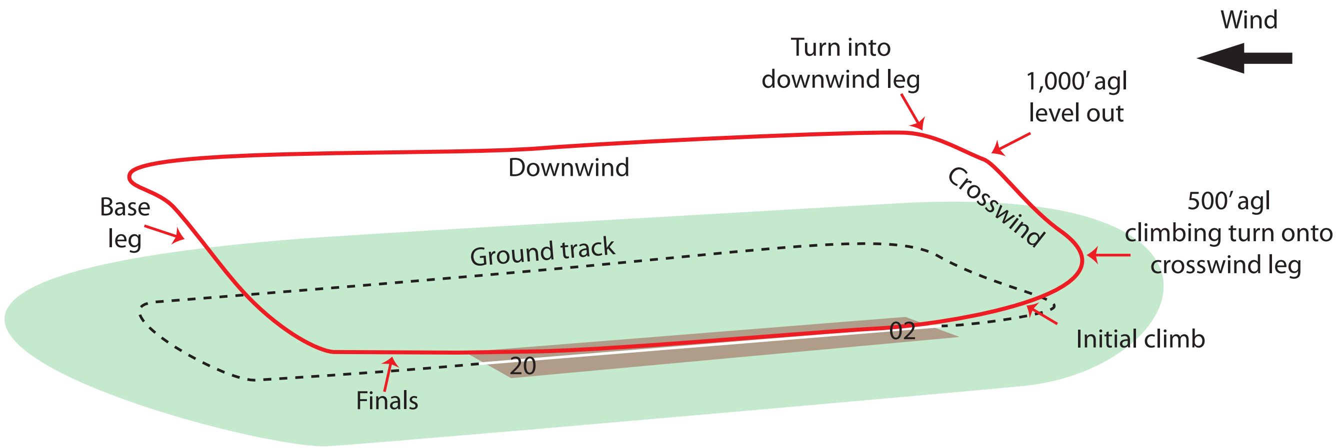
The standard circuit at UK civil aerodromes is set out in Figure 5 below.

The CAA publishes a *Guide to Visual Flight Rules in the UK* which states:

> *'...however, because of the diverse nature of aircraft types, performance and the application of local requirements it is not possible to define an actual common pattern for use at all aerodromes.'*

The crosswind join into the circuit

The crosswind join is a shortened adaptation of the standard overhead join. It requires an aircraft joining the circuit to cross the upwind end of the runway at 90°, at circuit height, giving way to aircraft already in



The Standard Circuit

Figure 5

The standard circuit, adapted with permission from *The Private Pilot's Licence Course* by J M Pratt[1]

Footnote

[1] The Private Pilot's Licence Course, Jeremy M Pratt, published by Airplan Flight Equipment, 2001.

the pattern. Aircraft requested to 'report crosswind' do so at that point, as they pass from the 'dead side' into the 'live' circuit, and they are then deemed to have joined the circuit. The aircraft then continues on its track until intercepting the downwind leg and turns into the normal circuit pattern at the 'downwind' position, abeam the upwind end of the runway.

The CAA's General Aviation Safety Sense Leaflet 6e, *Aerodrome Sense,* provides advice to pilots for aircraft arrivals at aerodromes. It includes the following guidance:

> *'Keep a good lookout, using others' radio calls to help identify all traffic joining or already in the pattern. Give way to aircraft already in the pattern.'*

Shoreham Airport

The *UK Aeronautical Information Publication* (AIP) provides published information for Shoreham Aerodrome. Regarding *Use of Runways,* the following is included:

> *'b. Runway 02/20 will always be preferred subject to operational limitations. Aircraft departing Runway 20 should avoid overflying as much of the built up areas to the south as is practical*
>
> *c. Circuit heights are 1100 ft aal for all runways…*
>
> *f. Aircraft joining direct to the crosswind leg should arrange their flight to track over the upwind end of the runway-in-use, ie in the same position as if approaching it from the 'deadside'. Unless otherwise instructed, this should be at circuit height.'*

Under *Noise Abatement Procedures,* the AIP states:

> *'Noise abatement techniques should be practiced at all times, the area to the east and west being particularly sensitive.'*

The Shoreham Airport circuit patterns for the various runways are published on their website and in certain flight guides. The indicated ground tracks are representative and for guidance. The website states that:

> *'Departure Runway 20 - aircraft must make a 10 degree turn to the right at the railway line for noise abatement until reaching the coast then a further left or right turn as required.'*

Circuit positioning

GC's first downwind leg was 0.7 nm from the runway centreline and on its second circuit, at the time of collision, the aircraft was 0.8 nm from the centreline. Based on interview, the PF of ZR intended to fly downwind between 1.3 and 1.7 nm from the centreline.

The time for an aircraft travelling at 90 knots from the crosswind joining position to the downwind leg, flown by GC, would have been about 32 seconds. From the time of ZR's radio call to the collision was 28 seconds.

See-and-avoid

In '*The Australian Transport Safety Bureau report on the Limitations of the See-and-Avoid Principle*[2]' it states that:

Footnote

[2] Limitations of the See-and-Avoid Principle; ATSB Research Report, April 1991, http://www.atsb.gov.au/publications/1991/limit_see_avoid.aspx

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

…In determining visibility, the colour of an aircraft is less important than the contrast of the aircraft with its background. Contrast is the difference between the brightness of a target and the brightness of its background and is one of the major determinants of detectability (Andrews 1977, Duntley 1964). The paint scheme which will maximise the contrast of the aircraft with its background depends of course, upon the luminance of the background. A dark aircraft will be seen best against a light background, such as bright sky, while a light coloured aircraft will be most conspicuous against a dull background such as a forest.

…Lack of relative motion on collision course

The human visual system is particularly attuned to detecting movement but is less effective at detecting stationary objects. Unfortunately, because of the geometry of collision flightpaths, an aircraft on a collision course will usually appear to be a stationary object in the pilot's visual field.

If two aircraft are converging on a point of impact on straight flightpaths at constant speeds, then the bearings of each aircraft from the other will remain constant up to the point of collision.

From each pilot's point of view, the converging aircraft will grow in size while remaining fixed at a particular point in his or her windscreen.'

Traffic alerting systems

Studies in 1991[3] showed that alerted see-and-avoid is eight times more effective than unalerted. There is no requirement for traffic alerting systems to be fitted to light aircraft. Both GC and ZR were operating Mode S transponders and both were equipped with EFIS displays that could have been fitted with a traffic alerting system. Stand-alone alerting systems were also available.

Previous AAIB safety recommendations

Following the mid-air collision between G-BOLZ and G-EYES, in the circuit at Coventry Airport in 2008[4], the AAIB made Safety Recommendation 2010-003, which related to Section 2 of MATS, Part 1. It stated:

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

The CAA accepted this recommendation. In July 2011, they updated the AAIB with their progress, stating that they had:

'Completed a detailed and comprehensive Air Traffic Standards Division (ATSD) safety review,

Completed a documentary review,

Were undertaking a UK incident data review,'

Footnote

3 Unalerted Air to Air Visual Acquisition, J W Andrews, November 1991, Massachusetts Institute of Technology.

4 AAIB Aircraft Accident Report 8/2010.

Following the mid-air collision between G-BYXR and G-CKHT in 2009[5], the AAIB made Safety Recommendation 2010-041. It recommended that:

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

The CAA accepted this recommendation and in March 2011 updated the AAIB with their progress. The CAA highlighted the complexities of the situation and the difficulties of finding a certificated but low cost and low power solution, such that it could reasonably be mandated to the large number of light aircraft and gliders on the UK register. The CAA concluded that no short term solution was available but, through the Future Airspace Strategy (FAS) and the Airspace & Safety Initiative (ASI), they would establish a cooperative workstream to address electronic conspicuity.

Other ongoing safety action

CAA visibility study

In September 2011, partly in response to the 2009 fatal collision involving G-BYXR and G-CKHT[6], the UK CAA announced that it was to fund research into improving the visual conspicuity of light aircraft and gliders. The CAA commented that:

> *'...being constructed of white composite materials many of these aircraft can be very difficult to spot when airborne.'*

Footnote

[5] AAIB Aircraft Accident Report 5/2010.
[6] AAIB Aircraft Accident Report 5/2010.

Analysis

Engineering

The tips of the detached left tailplane and left elevator from GC and the mid-span bisection of its left elevator showed that both had been caused by contact with the propeller of ZR. Both halves of the elevator had remained attached to the aircraft, the outboard half by the outer hinge and the inboard half by the torque tube. Upon impact with the ground, the outboard half had detached whilst the inboard half had remained with the main wreckage.

The recovered vertical fin and rudder of GC showed evidence of a distinct, horizontal crease caused by an object approximately halfway up the fin. This was on the left side and it was possible to match the imprint in the metal fin with the missing segment of the leading edge of ZR's left wing. It became clear that the two aircraft had been travelling at right angles to each other at impact and it was possible to determine the following sequence of contact, established using relative speeds derived from the radar records of both aircraft and an assumed propeller speed for ZR.

The first contact was between one propeller blade of ZR (rotating clockwise when viewed from behind) and the tailplane and elevator of GC, removing the tips of the left tailplane and elevator and destroying the wooden propeller blade of ZR (see Figure 6a).

As relative movement of both aircraft continued, a second propeller blade from ZR was in contact with the elevator further inboard, separating it into two halves (see Figure 6b). The severe out-of-balance forces rapidly fractured ZR's reduction gear casing and the propeller detached.

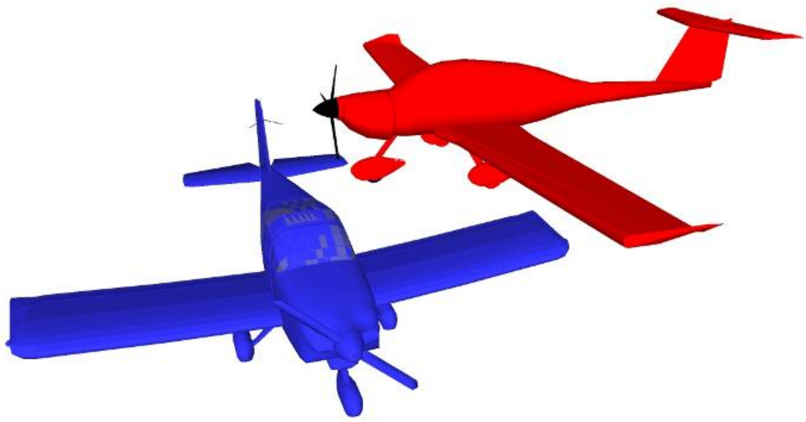


Figure 6a

Modelling of collision sequence (G-CEZR in red and G-RVGC in blue)

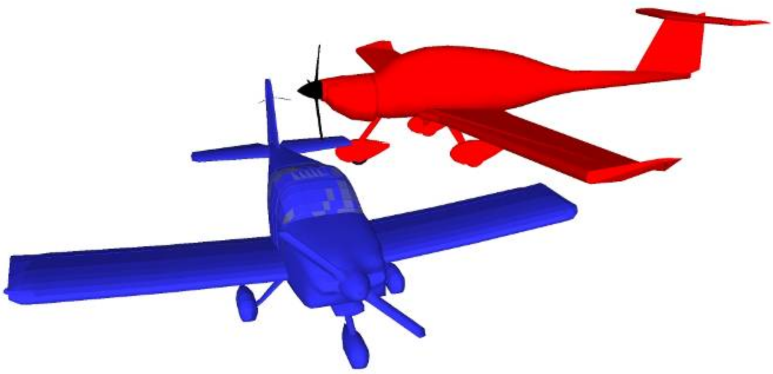


Figure 6b

Modelling of collision sequence

Figure 6c

Modelling of collision sequence

The third point of contact was between the fin/rudder of GC and the left wing leading edge of ZR; this contact detached the fin/rudder of GC (see Figure 6c).

There was no further contact between the two aircraft, but GC would have been left with no yaw control and severely impaired (or possibly jammed) longitudinal control. The leading edge damage to ZR would have caused some drag increase on the left side but clearly the pilot was able to overcome this and perform a successful forced landing without power.

Operations

General

From eyewitness accounts and recorded data, both aircraft approached each other in broadly straight and level flight prior to the collision. Neither of the crew of ZR saw GC before the collision and the flight path of GC suggests that its pilot did not see ZR. The rules of the air require pilots to undertake certain actions, in order to avoid collisions. However, this is only possible if the pilots involved are aware of the position of the other aircraft.

Each aircraft was following the correct circuit pattern and was at the correct height at the time of the collision. Also, ZR's crew made their crosswind radio transmission in the correct position, as they crossed the upwind end of Runway 20 at an angle of 90° and joined the 'live' circuit.

GC's downwind leg was closer to the runway centreline than the crew of ZR were intending to fly on their downwind leg. However, beyond following the circuit pattern, there was no requirement for either aircraft to follow a specific ground track or overfly particular turning points in the circuit, apart from the noise abatement procedure while taking off from Runway 20. The radar data indicated that GC complied with this procedure.

The advice to pilots joining a circuit on the crosswind leg and the rules regarding converging aircraft indicate that ZR should have given way to GC. However, this depended on ZR's crew being aware of and seeing GC. Also, each aircraft commander had a duty to take all possible measures to ensure that his aircraft did not collide with any other aircraft. Again, this relied on each commander seeing the other aircraft.

Situational awareness

The ATCO's traffic information to ZR of "TWO IN THE CIRCUIT" alerted the pilots to look for other aircraft and, approaching the airfield, the PF believed they were aware of the approximate locations of the aircraft referred to. At the time, GC was landing for a touch-and-go, G-RZ was further back in the circuit, late downwind or on base leg, and G-ET was at the holding point, about to line up and depart before G-RZ landed. The ATCO's radio call and phraseology was correct. However, it is possible that G-ET's departure introduced a risk of misidentification, depending on whether the aircraft was on its takeoff roll or airborne when it was last seen. G-ET was cleared to take off 50 secs before ZR reported crosswind and 1 min 25 secs before G-RZ called on final approach for a touch-and-go.

Based on GC's first circuit, the ATCO believed that GC would be ahead of ZR on the downwind leg of the circuit and did not see a requirement to impose sequencing. Conversely, the PF of ZR, who had seen an aircraft on the runway, which he believed to be circuit traffic, considered that they would be ahead of it on the downwind leg. It is not certain that the aircraft, ZR's crew saw, was GC. If it was G-ET, that could have led the crew to dismiss it as a risk and may, therefore, have influenced their lookout for other circuit traffic.

It is not known what awareness the pilot of GC had of other aircraft in the circuit, and ZR in particular.

Sun position

The sun's position and angle, to the south-west and about 55° above the horizon, meant that it was unlikely to have affected the pilots' lookout. However, it may have affected the ATCO's who would have been looking generally towards the sun when looking for aircraft joining crosswind. The CAA acknowledges that composite aircraft can be difficult to see and, while the ATCO does not specifically recall the sun being a particular issue, the combination of factors may explain why ZR was not seen before it joined the circuit. The remainder of the approach to the collision occurred behind and at a high angle to the ATCO, making visual sighting unlikely.

Visual search

Visual search is not 100% effective and even in ideal conditions there is no guarantee that a conflicting aircraft will be sighted in sufficient time to avoid a collision. Studies show that a visual search is more likely to be effective when the searcher knows there is a target to find and approximately where to look for that target.

The ATCO had provided traffic information to ZR and this was sufficient to alert the pilots to the need to look for and acquire other traffic. They believed that they had sighted the circuit traffic and considered that it was not a collision risk. This information and ZR's crosswind joining call could also have alerted the pilot of GC to joining traffic.

Regardless of whether the crew of ZR had misidentified the departing aircraft or whether they had identified GC correctly, approaching the downwind leg they had a low expectation of encountering traffic. Therefore, their visual search was likely to be, at best, as effective as unalerted see-and-avoid.

It is not possible to know if the pilot of GC heard the crosswind call from ZR, or if he recognised the conflict posed by ZR and was actively looking for it.

Contrast

In order to acquire the other traffic visually, the pilot of GC would have had to see a white aircraft against a bright horizon. Likewise, the crew of ZR would have been required to detect a blue and white target against the background of the sea on a bright, sunny day. It is considered that neither of these targets would have contrasted strongly against their background.

Constant bearings

During the 24 seconds leading up to the collision, from the perspective of the crew in ZR, GC was on an approximately constant bearing. The ATSB report makes it clear that, due to the apparent lack of movement of the target, a constant bearing will reduce the probability of visual sighting.

Traffic alerting systems

In previous UK general aviation mid-air collisions a common AAIB finding is that the aircraft involved were not on a common ATC frequency or were not electronically conspicuous. As such, no form of alerting was practicable. However, in this collision both aircraft were transmitting Mode S data and both were equipped with EFIS systems capable of displaying traffic information. Neither aircraft was fitted with this optional equipment nor were they required to be. Had this equipment been fitted it could have been effective although it would not have detected aircraft not equipped with transponders.

Conclusions

Collision avoidance within an aerodrome circuit in Class G airspace is achieved by pilots visually acquiring conflicting traffic, aided by instructions or information from ATC and transmissions from other aircraft, and altering their aircraft's flightpath, as necessary.

Pilots' mental models of aircraft positions assist in deciding where to search visually. Visual detection is subject to numerous limitations and its success is not assured. In addition, there is a lower probability of seeing traffic if it is not where it is expected to be. Both aircraft commanders had a duty to take all possible measures to avoid a collision, in accordance with the Rules of the Air Regulations which specify who has right of way. However, the crew in ZR were not aware that an aircraft, which was on an approximately constant bearing, was approaching them from the right on the downwind leg, nor did they see it. Whether the pilot of GC was aware of ZR joining the circuit on the crosswind leg, or saw it is not known. There was no indication that he took any avoiding action, implying that he probably did not see ZR in time to avert the collision.

The CAA has recently conducted a review of light aircraft electronic conspicuity, is reviewing the MATS Part 1 requirements for ATCOs and is conducting a study aimed at improving composite aircraft visibility.