ACCIDENT

Aircraft Type and Registration:	Gulfstream III (G-1159A), N103CD
No & Type of Engines:	2 Rolls-Royce Spey Mk511-8 turbofan engines
Year of Manufacture:	1984 (Serial no: 418)
Date & Time (UTC):	24 November 2014 at 2030 hrs
Location:	Biggin Hill Airport, Kent
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - 5
Injuries:	Crew - None Passengers - None
Nature of Damage:	Aircraft damaged beyond economic repair
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	36 years
Commander's Flying Experience:	4,120 hours (of which 3,650 hours were on type) Last 90 days - 60 hours Last 28 days - 19 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft lined up for takeoff in conditions of reduced visibility. The crew believed that the lights they could see ahead were runway centreline lights when they were actually runway edge lights. The aircraft began its takeoff run but ran off the paved surface and onto grass. The commander closed the thrust levers to reject the takeoff.

Information available to the pilots allowed them to develop an incorrect mental model of their route from the holding point to the runway. Environmental cues indicating that the aircraft was in the wrong position for takeoff were not strong enough to alert the pilots to the fact that they had lost situational awareness.

One Safety Recommendation has been made.

History of the flight

On 24 November 2014 the crew of Gulfstream III N103CD planned for a private flight from Biggin Hill Airport to Gander International Airport in Canada. The weather reported at the airport at 2020 hrs was wind 'calm', greater than 10 km visibility with fog patches, no significant cloud, temperature 5°C, dew point 4°C and QNH 1027 hPa. At 2024 hrs, the crew was cleared to taxi to Holding Point J1 for a departure from Runway 03. After the crew read back the taxi clearance, the controller transmitted:

"We are giving low level fog patches on the airfield, general visibility in excess of 10 km but visibility not measured in the fog patches. It seems to be very low, very thin fog from the zero three threshold to approximately half way down the runway then it looks completely clear".

The crew acknowledged the information.

At 2028 hrs, the aircraft was at the holding point and was cleared for takeoff by the controller. The aircraft taxied towards the runway from J1 but lined up with the runway edge lights, which were positioned 3 m to the right of the edge of the runway. The aircraft began its takeoff run at 2030 hrs, passing over paved surface for approximately 248 m before running onto grass which lay beyond. The commander, who was the handling pilot, closed the thrust levers to reject the takeoff when he realised what had happened and the aircraft came to a halt on the grass having suffered major structural damage. The crew shut down the engines but were unable to contact ATC on the radio to tell the controller what had happened.

The co-pilot moved from the flight deck into the passenger cabin and saw that no one had been injured. He vacated the aircraft through the rear baggage compartment and then helped the commander, who was still inside, to open the main exit door. The commander and the five passengers used the main exit to vacate the aircraft.

The controller saw that the aircraft had stopped but did not realise that it was not on the runway. He attempted to contact the crew on the radio but, when he saw the lights of the aircraft switch off, he activated the crash alarm, at 2032 hrs, declaring an aircraft ground incident. At 2034 hrs the airport fire service reached the aircraft and declared an aircraft accident, after which the airport emergency plan was activated.

Information from the crew

The crew had reported at 1840 hrs for a 2030 hrs departure and noticed that there was moisture from the mist on the aircraft windshield. As they taxied they were aware that there was some patchy ground fog and, as the aircraft turned onto the runway heading, they noticed that the runway lights had a "glow" around them as did more distant lighting. They did not consider the conditions to represent a hazard and there was "nothing widespread or thick".

Both crew members were expecting the runway to have centreline lighting.

The crew stated that the aircraft was normally operated under Part 91 of US Federal Aviation Regulations which leaves takeoff visibility requirements to the discretion of the aircraft commander. The commander stated that he preferred visibility at takeoff to be equivalent to between one quarter and one half of the runway length and he had believed he had sufficient visibility for this takeoff.

Information from the ATC controller

The ATC controller stated that the weather had been CAVOK during the afternoon. Subsequently, the wind dropped and some low level thin mist, which "appeared like steam", could be seen drifting across the airfield. Later, there were some patches of fog approximately "waist deep" from abeam the control tower towards the southern end of the runway but it was clear to the north. At 2005 hrs, a fire command vehicle had driven along the runway for a wildlife inspection and had reported the visibility as being "good". The controller reported that, after the aircraft came to a halt, he could see only the top of the fuselage and tail above the layer of fog.

The controller stated that the airport was unable to measure and report runway visual range (RVR) in respect of the departure end of Runway 03.

Accident site

Biggin Hill was originally a military airfield and at the beginning of Runway 03 is a 250 m long and 36 m wide paved surface, with a 30º slant to the runway, called an Operational Readiness Platform (ORP). While there are no markings at the start of the ORP to indicate that aircraft should not enter this area[1], a section of the ORP between the runway and Taxiway C has been painted with yellow hatching (Figure 1). Grass and weeds have grown in the gaps between the concrete segments in the ORP. Four surface-mounted red runway edge lights, evenly spaced 61 m apart, were positioned approximately 3 m from the white

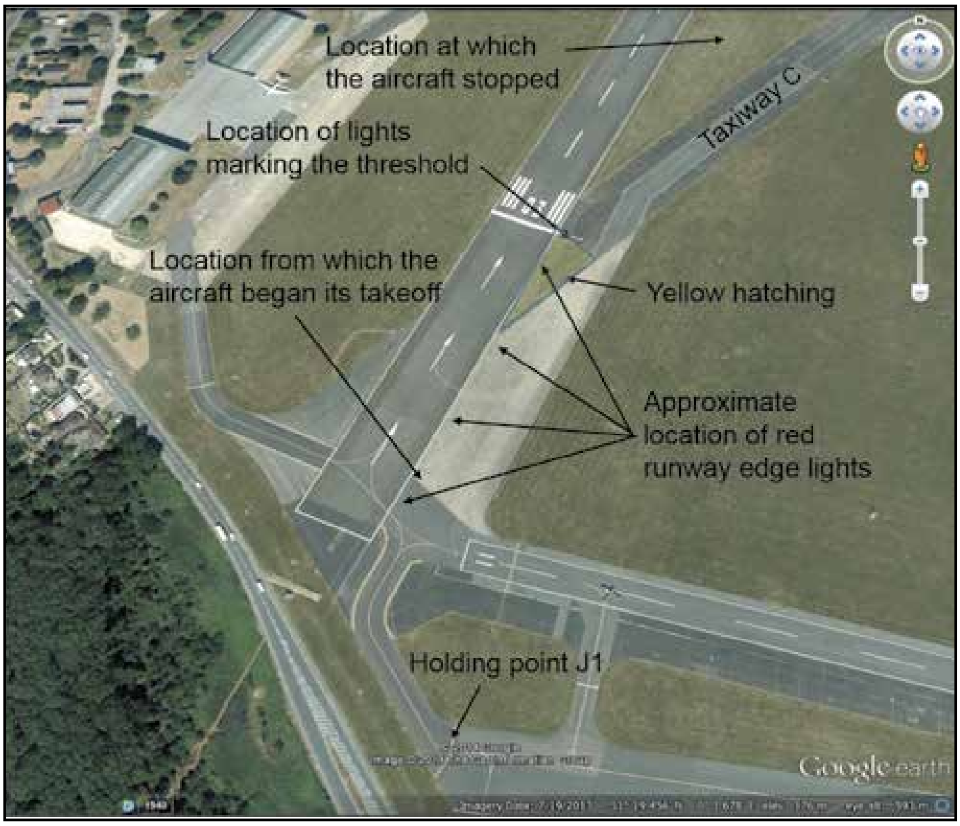

Figure 1

The area near the threshold of Runway 03

Footnote

[1] See later section, *Taxiway markings.*

line that marked the edge of the runway. The most northerly light was located 30 m from the threshold of Runway 03 (Figure 2). Beyond the lights marking the runway threshold, white runway edge lights were mounted on poles located in the grass.

Marks made by the aircraft tyres showed that on exiting Taxiway J the aircraft entered the ORP with the left main wheels in line with the red runway edge lights. When the aircraft began its takeoff run, it had passed the first red runway edge light and the next edge light ahead of the aircraft was approximately 46 m away. The aircraft track continued parallel to the runway and 248 m from the start of the ORP the aircraft left the paved area and ran onto the grass. All the wheels sank approximately 0.25 m into the soft ground; however, the depth of the furrow made by the nosewheel varied, indicating that the aircraft was oscillating about the main landing gear. After travelling 120 m across the grass the nose landing gear and radome detached. The aircraft eventually came to a halt 424 m from the start of the ORP, in line with the PAPI. After passing the threshold lights, the left main wheel damaged two of the three white edge lights.

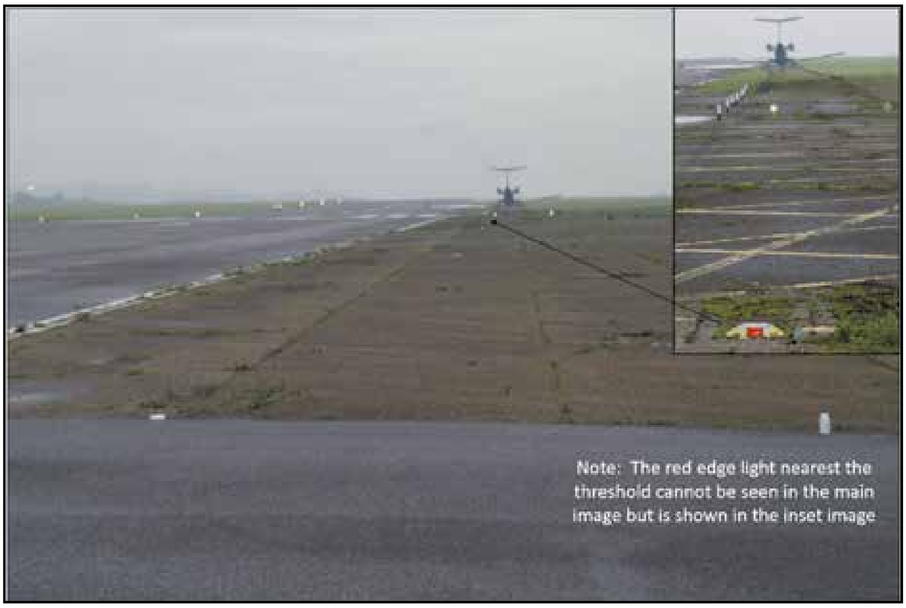

Figure 2

Red lighting on the ORP and the ORP's boundary with the taxiway

Damage to the aircraft

After the nose landing gear separated from the aircraft, it struck the lower fuselage approximately 0.3 m aft of the nose landing gear bay, tearing a hole in the skin 6.5 m long. A number of frames in this area were damaged and all the aerials mounted on the forward lower section of the fuselage were found detached. There was also a crease and rupture in the skin over the top of the fuselage, just aft of the second window in the cabin (Figure 3). The aircraft was assessed as being beyond economic repair.

Figure 3

The aircraft as it came to rest, showing area of skin crease and rupture

Recorded data

Flight recorders

The aircraft was fitted with a 30-minute CVR and a 25-hour FDR. The CVR was a tape-based recorder but the mechanism drive motor had failed, so there was no recording relevant to this accident. The CVR was due to be checked on 30 November 2014.

An FDR was fitted although there was no requirement to do so. It only had a basic parameter set and the data was not sufficiently reliable to be used in this report. The only FDR-related scheduled maintenance was associated with the underwater locator beacon attached to the FDR.

iPad tablets

Three iPad tablets were recovered from the aircraft and the path of the aircraft during the attempted takeoff was recorded by 'apps' installed on two of them. These tablets use built-in GPS receivers as part of their positioning capability, which are less effective when used within an aircraft. However, whilst the accuracy of the recorded tracks is not known, the two recordings were largely consistent with each other. One of the recordings started at 1956 hrs but no motion was recorded until 2025 hrs and the motion stopped at the final location of the aircraft at 2030 hrs. The recorded ground speed reached a maximum of approximately 70 kt during this period. The path recorded by the iPads is shown in Figure 4.

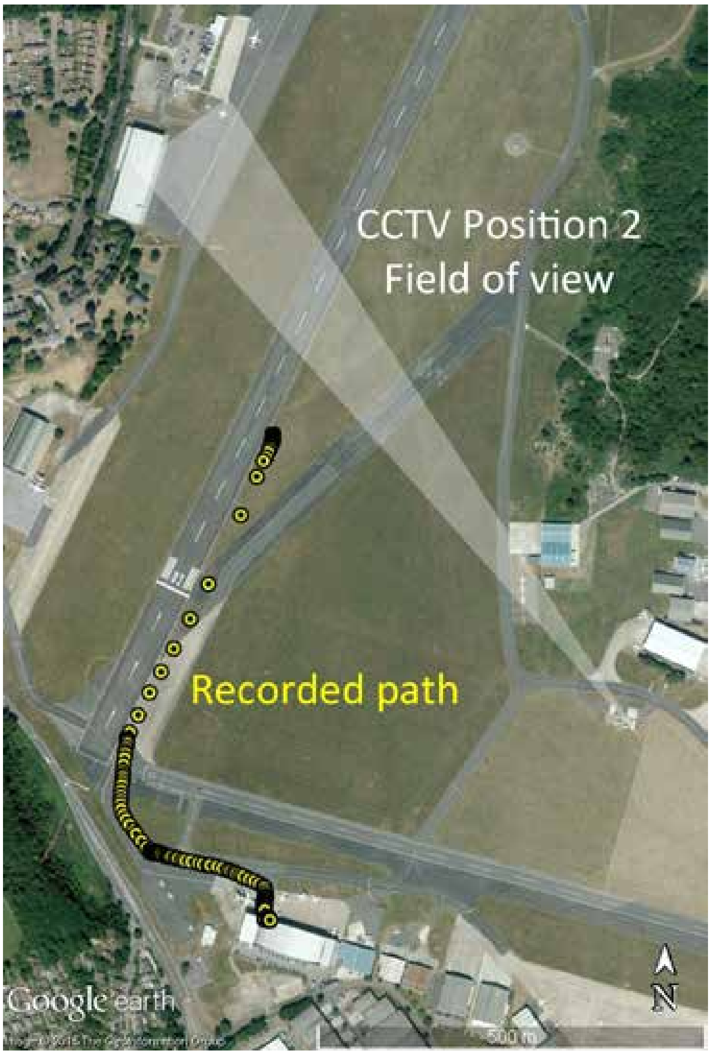

Figure 4

Recorded path of the aircraft and relevant CCTV image coverage

CCTV

A CCTV camera was installed to the east of the runway. The camera can be panned in a complete circle and zoomed. At the time of the accident it was stepping through a sequence of direction/zoom combinations, known as 'Positions', which repeated every 1 minute and 25 seconds. The field of view whilst at Position 2 is shown in Figure 4 and snapshot images whilst in this position are shown in Figure 5.

Figure 5 illustrates the low-level fog patches drifting across the airfield during the accident period, and the patches are also prevalent in the rest of the recording, in which their movement is seen more clearly. The CCTV snapshots were taken from the side of the runway, so only the low-intensity omnidirectional components of the runway edge lights were captured, and not the high-intensity directional component as viewed when looking along the runway.

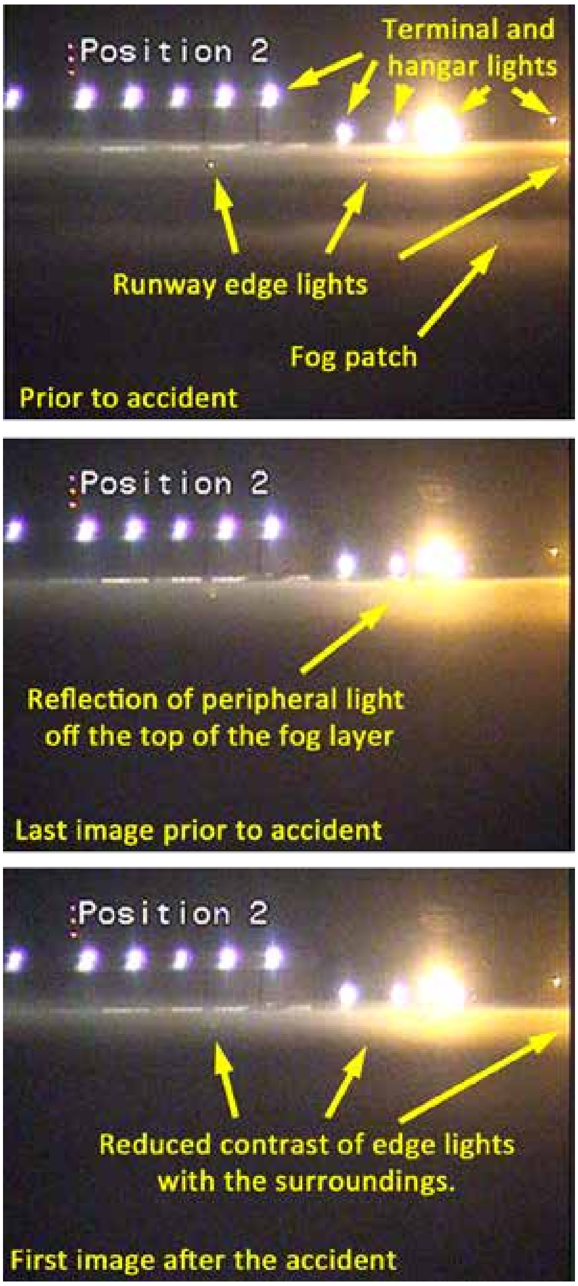

Figure 5

CCTV images from Position 2 taken 1 minute 25 seconds apart

The lights associated with the hangars, terminal and apron areas are significantly brighter than the runway lights. The CCTV images do not fully represent the extent of this as the image brightness of the peripheral lights (such as those at the apron and the terminal) was recorded at the maximum brightness the image can represent. Therefore the contrast in actual brightness was greater than the images in Figure 5 indicate.

Aerodrome information

The aerodrome chart used by the crew was contained in an iPad app which was updated through a subscription service with the product supplier. The authoritative source for the aeronautical information contained within the app is the Biggin Hill Airport Aerodrome Chart contained in the UK Aeronautical Information Publication (AIP), maintained by NATS AIS. Sections of the iPad and AIP charts showing the area between Holding Point J1 and the beginning of Runway 03 are shown in Figure 6. The path that an aircraft must follow after passing Holding Point J1 is shown by the yellow taxiway markings in the 'Overhead view' within the figure.

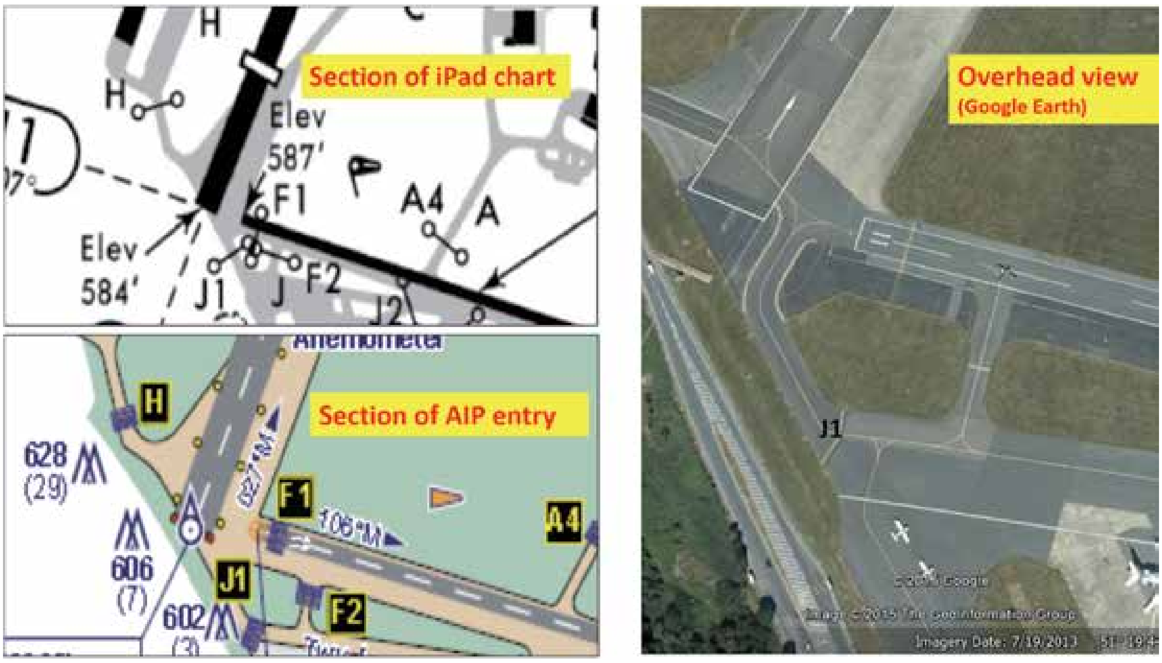

Figure 6

Taxi route from J1 to Runway 03

The AIP entry for Biggin Hill Airport contains information on the use of runways in section AD 2.20, *Local Traffic Regulations*. It states in paragraph 6 (a):

> *'The width at both ends of Runway 03/21, is twice that delineated by the associated edge lights due to extra pavement at one side. Since runway centre-line lighting is not installed, pilots should ensure that they are correctly lined up, especially if take-off is at night or when the runway is contaminated or in low visibility.'*

This information was not available to the crew in their charts.

Commercial chart suppliers

Operators of commercial aircraft are regulated and audited against a requirement to provide up-to-date route documents to their crews. Companies supplying the documents are not regulated but can apply for a Letter of Acceptance (LOA) from EASA (or the FAA) as a navigation database supplier. A condition of receiving an LOA is that a company submits itself to a voluntary audit by the regulator in respect of its quality system for the processing of data[2]. The provider of the charts used by the crew in this accident has relevant LOAs from the FAA and EASA.

Each chart supplier uses its own format for presenting data obtained from national AIPs, which are themselves compiled using different formats and languages. Chart suppliers do not reproduce the entire AIP entry for every airport they cover because the result would be unusable by flight crew in an operational environment. An editorial process is required to decide which data, or changes to data, should be included in the published charts. This editorial process involves reviewing data for applicability against company specifications/ processes, or Service Level Agreements (SLAs) in respect of contracts with specific operators. In response to this investigation, the chart supplier stated that:

> *'All AIP source from the United Kingdom is reviewed and checked it against [the Company's] Specifications in order to determine whether source content should be applied to specific charts or airport directories.'*

Applicable regulations

N103CD was operated within the USA under Federal Aviation Regulation (FAR) Part 91, '*General Operating and Flight Rules*'. Part 91 describes rules for operating aircraft within the USA including over waters within 3 nm of the coast. Subpart H to Part 91, is applicable to the operation of USA-registered civil aircraft outside the USA. Article 91.703 (a) (2) states that persons operating outside of the USA shall:

> *'When within a foreign country, comply with the regulations relating to the flight and maneuver of aircraft there in force.'*

Civil Aviation Publication (CAP) 393, '*Air Navigation: The Order and the Regulations'* dated May 2014 was applicable to this flight. Part 14, '*Operating Minima and Equipment Requirements for Aerial Work and Private Aircraft'* stated at Article 109 (2) that an aircraft:

> *'must not take off when the relevant runway visual range is less than 150 m otherwise than under and in accordance with the terms of an approval to do so granted in accordance with the law of the country in which it is registered.'*

CAP 746 Meteorological Observations at Aerodromes

Civil Aviation Publication (CAP) 746, '*Requirements for Meteorological Observations at Aerodromes',* discusses the reporting of visibility in Chapter 4. The visibility reported in a METAR[3] is the 'prevailing' visibility and, in some circumstances, the minimum visibility. The 'prevailing' visibility is defined as:

Footnote

2 The relevant Standards for processing aeronautical data are RTCA DO-200A or Euro CAE ED-76. ASI 9001 is a Standard for quality management within the aerospace industry.

3 METAR is the format for reporting weather observations.

> *'the greatest visibility value that is reached within at least half the horizon circle or within at least half of the surface of the aerodrome. These areas could comprise contiguous or non-contiguous sectors.'*

If the visibility in another direction is less than 1500 m, or less than 50% of the prevailing visibility, then it is also reported.

Fog is reported when the prevailing visibility is less than 1,000 m and fog patches are reported when:

> *'fog, 2m or more deep, is present on the aerodrome in irregularly distributed patches. The meteorological visibility reported will depend on the proximity of the nearest fog patch to the observer.'*

Lighting

Visibility from the Gulfstream III cockpit

In response to a question from the AAIB on the visibility to the crew of runway features ahead of the aircraft, the manufacturer stated that, for a pilot in the normal sitting position within a Gulfstream III standing on the ground, approximately 13.1 m of pavement ahead of the pilot's eye is obscured by aircraft structure.

Aerodrome lighting

The CAA guidance document CAP 168, '*Licensing of Aerodromes*', discusses aerodrome lighting in Chapter 6, '*Aeronautical Ground Lighting*', and was used as the reference document in this investigation. Standards associated with aerodrome lighting and, more specifically, runway lighting are derived from ICAO Annex 14, Volume 1, '*Aerodrome Design and Operations*'. For the UK, responsibility for the regulation of aerodromes is passing from the CAA to EASA.

Paragraph 6.58 of CAP 168 details requirements for runway edge lights. The text relevant to this investigation states:

> *'Runway edge lights should be white except …, where a threshold is displaced, the lights between the beginning of the runway and the displaced threshold should show red in the approach direction'; and*
>
> *'White runway centreline lights are required for takeoff in RVR below 400 m and for precision instrument approach runways Category II and III.'*

Runway 03 at Biggin Hill does not have centreline lighting and cannot be used for takeoffs in RVRs below 400 m. Its edge lights are white but, because the runway has a displaced threshold, edge lights between the beginning of the runway and the threshold show red in the approach direction.

The white runway edge lights in use at the aerodrome have an omni-directional element and a bi-directional element and are raised above the ground. The minimum intensity of the omni-directional element is stipulated as 200 cd[4]. The intensity minimums for the bi-directional element depend on the angle it is being observed from, both laterally and vertically, and are shown in Figure 77 for a 45 m wide runway. The intensity of runway lighting is adjusted depending on ambient light levels but the intensity settings are not logged by the aerodrome authority.

The only CAP 168 requirement relating to peripheral lighting is a minimum lighting level in apron areas and there are no requirements relating to this light 'spilling' onto other areas of the aerodrome.

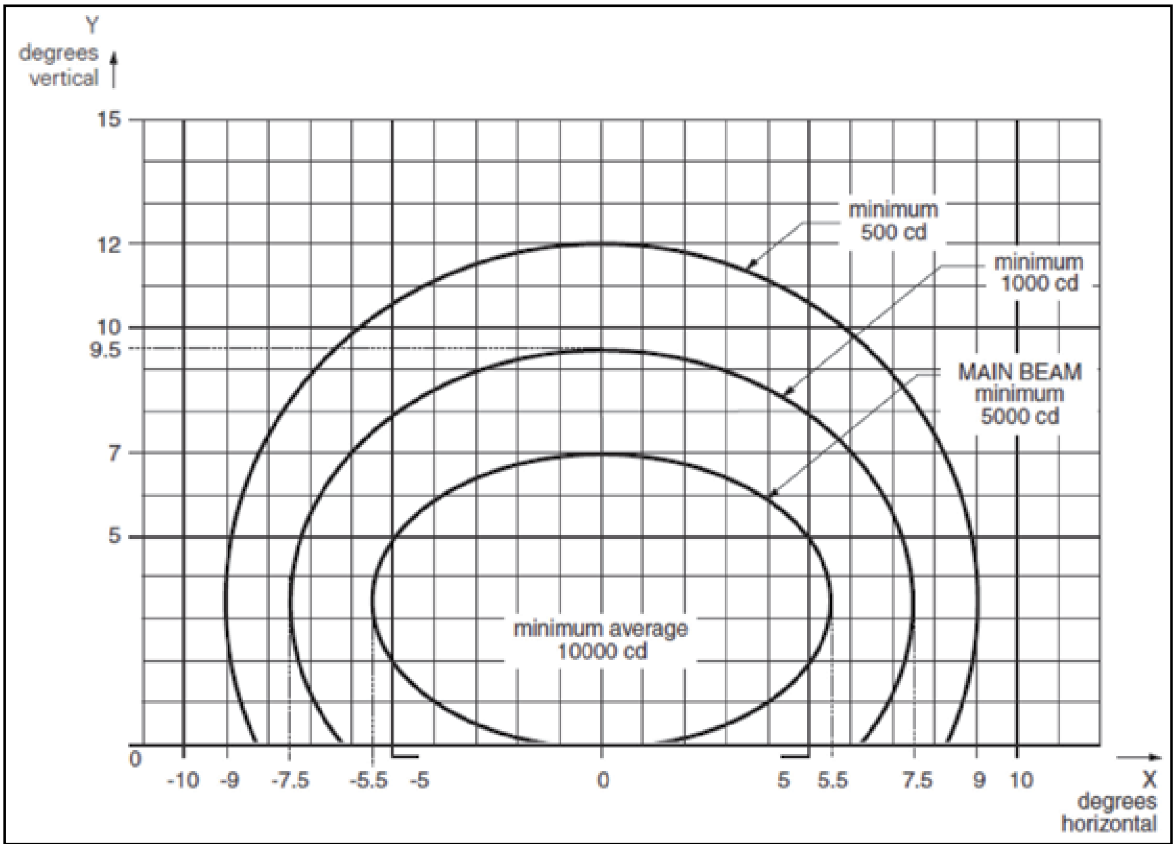

Figure 7

Requirements for the directional element of runway edge lights
(extracted from Figure 6A.9 of CAP 168)

Light intensity

When on the runway centreline, each successive pair of left and right runway edge lights will appear equally bright. For the lights closest to the aircraft only the omnidirectional part will be visible, but the main beam (directional element) will become progressively more visible for the lights further along the runway. However, when positioned in line with one

Footnote

[4] The Candela (cd) is the SI base unit of luminous intensity.

set of edge lights, the pilot will be looking at the highest intensity part of every light along that edge. Edge lights on the other side of the runway will need to be twice as far along the runway, compared to the aircraft-centred scenario, before the main directional beams become visible. This would make the edge lights with which the pilot was aligned a visually compelling line, whereas the corresponding edge lights on the far side of the runway would have been less visible and may not have appeared to the pilot as a line.

To show this point, Figure 8 illustrates the modelled illuminance of the edge lights from the approximate start position of the accident flight, using the minimum light intensity values given in the standards. This assumes the lights were set at 100% power and, as an indicative value, uses 1 km visibility.

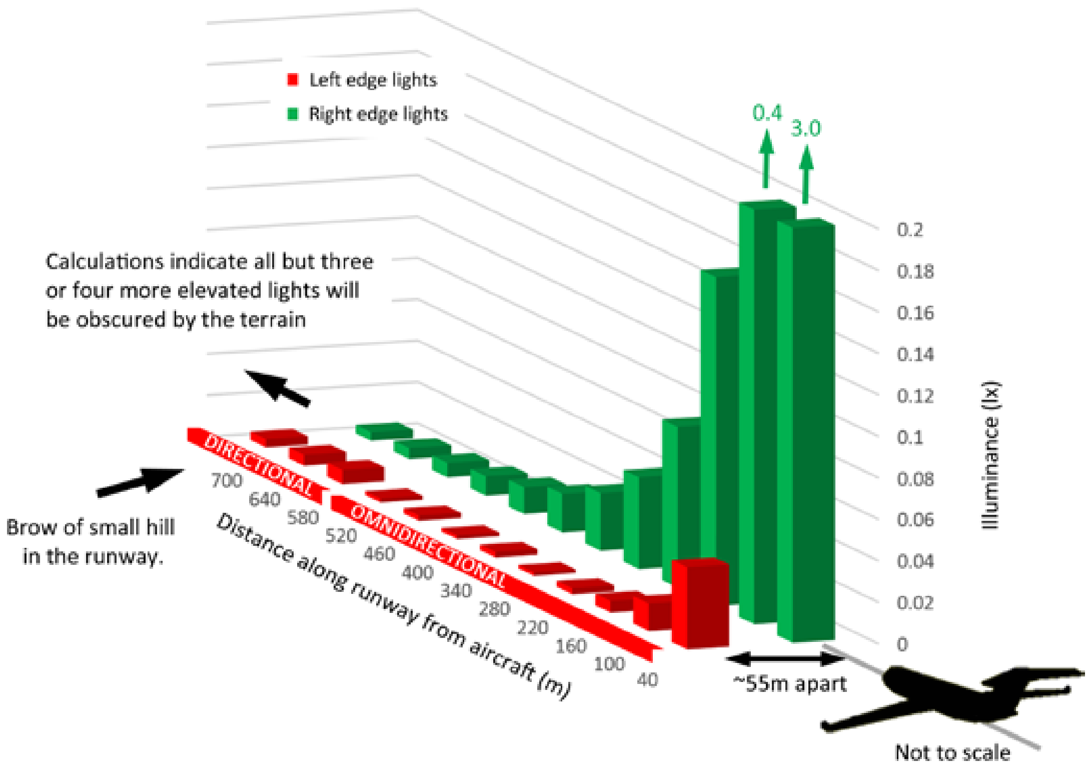

Figure 8

Illustration of light intensity of a combined omnidirectional and bi-directional runway edge light, assuming optimal vertical viewing angle and 1 km visibility

Light technology

Lighting standards are largely based on the tungsten light bulb technology that was prevalent at the time the standards were promulgated. LED lighting technology has since improved the capability of lights to hold colour over varying power ranges and over time, and has improved directional control of lighting.

Contrast

The human eye can cope with very high and very low light intensity conditions, but there is a limit to how much contrast the eye can perceive at any given time, so bright lights degrade the eye's ability to detect dim lights. For the illustrative 1 km visibility conditions used for Figure 8, the contrast between the nearest edge light and one 500 m further down the runway was calculated as more than 300:1. Reducing the visibility increases the contrast between lights close to the aircraft and those further away, making it more difficult for the eye to detect the distant lights. The eye's ability to detect a low-intensity light, attenuated by fog, will be degraded by the halo-effect of other higher intensity lights shining through the fog. A similar problem occurs if the viewer and high-intensity lighting are outside the fog layer that the light of interest needs to penetrate, due to the scattered reflection of the higher intensity lights.

The actual threshold of the pilots' ability to detect light in any particular direction at the time of the accident is not known.

Taxiway markings

The requirements for taxiway markings are contained in Chapter 7 of CAP 168 which states in paragraph 7.108:

> *'Where it is necessary to define the outer edges of a taxiway, e.g. … where a taxiway lies adjacent to a paved area not intended for use as a taxiway, the outer edges of the taxiway should be marked* [as shown in Figure 9]*':*

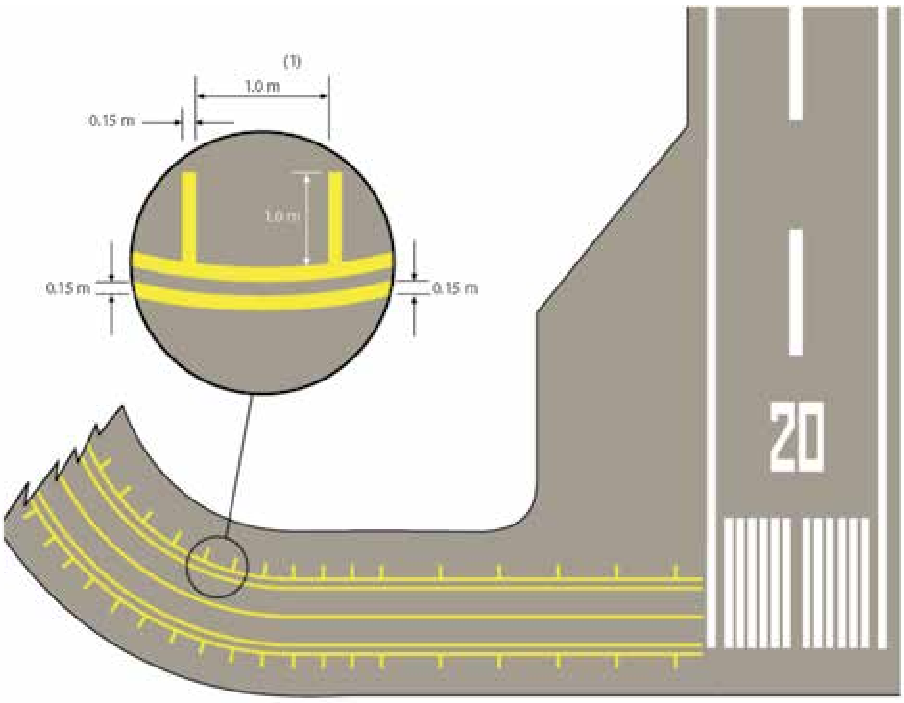

Figure 9

Extract of CAP 168 showing taxiway edge markings at a representative aerodrome

The eastern side of the ORP at the beginning of Runway 03 at Biggin Hill Airport is used as Taxiway C and the boundary between the southern end of the ORP and Taxiway J was not marked as shown in Figure 9 at the time of the accident.

Previous events

The CAA MOR database contained 13 recorded events involving misidentification of runway edge lights as centreline lights. This covered a period from 1982 to 2015 and involved 11 different aircraft types and nine different airfields. These included three AAIB investigations:

1. ATR42-300, G-TAWE, at Prestwick on 22/1/2006
   (AAIB reference EW/G2006/01/16)

2. Piper PA-34-200T, G-MAIR, at Bristol on 12 December 1996
   (AAIB reference EW/C96/12/3)

3. Fokker F27 Mk 200, G-BHMX, at Teeside on 7 December 1990
   (AAIB reference EW/C1186)

A further search for similar events from other countries found, as examples: a Cessna 402B at Chicago Midway in 1999, an ATR 72 at Dresden in 2002, an A319 at Las Vegas in 2006, an Embraer 190 at Oslo in 2010, a CRJ200 at Dubai in 2011 and an A330 at Abu Dhabi in 2012.

Factors influencing misaligned takeoffs at night

In 2009-2010 the Australian Transportation Safety Board (ATSB) produced a report, '*Factors influencing misaligned take-off occurrences at night*'[5], which showed that this type of event occurs around the world and is not limited to a particular aircraft type or operator.

The report discussed environmental factors relating to misaligned takeoffs, which included the weather and the physical environment. The report stated:

> *'Confusing runway entry, lighting or taxiway layout/lighting was the most frequent environmental factor identified. Also common was [the layout of] the area around the entry to the runway and beyond the edge of the runway (e.g. extra pavement in that area); and the width of the runway and the lighting layout, colour and intensity.*
>
> *Areas of additional pavement around the taxiway entry and runway threshold area can provide erroneous visual cues for pilots at night. Pilots operating from a runway with a greater width (or additional paved areas at taxiway entry) than most standard runways can believe that they are in the centre of the runway when they are actually lined up on the edge.*

Footnote

[5] Available: http://www.atsb.gov.au/media/1543486/ar2009033.pdf

The importance of the colour, positioning and intensity of taxiway and runway lighting was highlighted in the events reviewed. During night operations, flight crew rely heavily on taxiway lead-in lights and available runway lights to position the aircraft correctly for takeoff. In some cases, [crew] believed the lights were the correct colour when they were not.

Aircraft using a displaced threshold will not be able to see the normal threshold markings, such as the runway number or 'piano keys', which provide important cues during the line-up phase of flight. If the runway does not have centreline lighting, it may be less evident to the pilots that the aircraft is lined up on the edge lighting given the limited cues available from the displaced threshold.'

The report concluded:

'The following were identified as the most prevalent safety factors in the data reviewed. In all occurrences, one or more of these factors were present and contributed to the event. Each of these factors may increase the risk of a misaligned takeoff occurrence:

a. Night time operations

b. The runway and taxiway environment, including confusing runway entry markings or lighting, areas of additional pavement on the runway, the absence of runway centreline lighting, and recessed runway edge lighting.

c. Flight crew distraction (from within the cockpit) or inattention.

d. Bad weather or poor/reduced visibility.

e. Conducting a displaced threshold or intersection departure.

f. Provision of air traffic control clearance when aircraft are entering the runway or still taxiing.

g. Flight crew fatigue.'

Safety actions

Biggin Hill Airport

Before the accident to Gulfstream N103CD the airport's Safety Management System (SMS) had identified a need to improve the lighting in the area surrounding the Runway 03 threshold. Some pilots landing on Runway 21 in the dark had been finding it difficult to identify the correct taxiway when vacating the runway near the threshold of Runway 03, and the decision had been taken to install taxiway lights in the area. Because the installation would require significant ground works, and the provision of a new lighting sub-station, it was not anticipated that the work would commence before the summer of 2015.

Following this accident, reflective studs were installed as a temporary measure to delineate the taxiways and runway access points around the Runway 03 threshold. Blue taxiway edge markers were installed leading from Holding Point J1 to the runway, and alternating yellow/green studs were installed on the taxiway centreline. In addition, a bar of red studs was placed across the southern edge of the ORP, along with taxiway edge markings (see Figure 9), to reduce the risk that crews following the taxiway around the first right turn after J1 would proceed straight ahead, as the aircraft in this accident did.

Chart supplier

Following this accident, the chart supplier decided to revise its Biggin Hill Airport Diagram Chart to include the information contained in Section AD 2.20, paragraph 6 (a) of the airport's entry in the UK AIP (see earlier section on Aerodrome information). It decided to include the information in its Chart Change Notices for the UK to cover the period until the revision was issued.

Analysis

Takeoff visibility

This was a private flight which could not depart in conditions of less than 400 m RVR. RVR cannot be measured at the threshold end of Runway 03 but the prevailing visibility was reported as being more than 10 km. The crew reported that there was moisture on the windscreen from the mist and they could see a "glow" around lights which were visible to them. They were also aware while taxiing that there was some patchy ground fog on the airfield. The ATC controller transmitted that visibility had not been measured in the fog patches but there seemed to be 'VERY LOW, VERY THIN FOG FROM THE ZERO THREE THRESHOLD TO APPROXIMATELY HALF WAY DOWN THE RUNWAY'. With hindsight, this piece of information is significant but, at the time, the crew did not consider the fog to be widespread or thick; operating under FAR Part 91 in the United States, they were used to making their own judgments as to whether the visibility was suitable for a takeoff. However, after the aircraft came to a halt following its abortive takeoff attempt, the controller could only see the top of the fuselage and tail above the layer of fog. It is likely, therefore, that the visibility was worse than the crew appreciated at the time N103CD taxied from Holding Point J1.

The route from J1 to the runway

The information on the aerodrome chart used by the crew, and the source of information in the UK AIP, suggested that the aircraft would be required to taxi in a straight line from J1 to the runway and then make a right turn onto the runway heading. In fact, in order to taxi from J1 onto the runway, an aircraft must: taxi in a straight line; follow a curve to the right onto runway heading but still displaced to the right of the runway itself; turn left towards the runway; and then turn right again onto runway heading.

Aerodrome lighting

The UK AIP states that there is no centreline lighting on Runway 03, and that the pavement width at the beginning of the runway is twice the normal runway width. It recognises the potential for confusion and urges crews to ensure that they have lined up correctly. This information was not available to the crew on their aerodrome charts and both crew members believed that the runway had centreline lighting. Further, the light from those left-side runway edge lights covered in fog would have been scattered, making it harder for the crew to perceive them as a distinct line of lights. The situation is likely to have been made worse by the bright lights reflecting off the top of the fog layer, making the underlying runway lights even harder to see, or swamping them completely as shown in Figure 5.

The CCTV images in Figure 5 show that peripheral lighting can interact with low fog layers to reduce the visibility of underlying aerodrome lighting. Current standards associated with apron lighting only address the minimum light levels required to make the areas safe and there are no standards relating to light spilling into other areas.

Human and environmental factors

Five of the factors identified by the ATSB as being present in misaligned takeoffs were present in this accident:

1. It was dark.
2. It was potentially a confusing taxiway environment given that the aerodrome chart did not reflect the actual layout of the taxiways. Pilots had previously reported having difficulty when vacating the runway near the Runway 03 threshold because of a lack of taxiway lighting.
3. There was an additional paved area (the ORP) near the runway.
4. There was no runway centreline lighting and the runway edge lights before the displaced threshold were recessed.
5. There was reduced visibility.

It appeared that the information available to the crew caused them to develop an incorrect expectation of their route to the runway. Both crew members believed that the runway had centreline lighting and, when the first right turn almost lined the aircraft up with some lights, their incorrect expectation was reinforced and they believed that the aircraft was lined up correctly. Cues to the contrary, such as runway edge lights on the other side of the runway, or the fact that the first three lights ahead of the aircraft were red (indicating that they were edge lights before the displaced threshold), did not appear to have been strong enough to make the crew realise that they had lost situational awareness. Figure 8 indicates that the apparent intensity of the white left-side runway edge lights was significantly less than that of the right-side lights, when viewed from the position where the aircraft lined up. This, along with other visual issues relating to contrast and the fog, is a plausible explanation as to why they were not noticed by the crew. The aircraft began its takeoff roll from a location beyond the first red runway edge light and approximately 46 m short of the next light, as shown in Figure 1. Aircraft structure only obscures approximately the first 13 m of pavement ahead of pilots within a Gulfstream III aircraft and therefore these lights would not have been obscured by the aircraft. However, it is likely that the recessed nature of the red edge lights before the displaced threshold made them less compelling than the elevated white edge lights beyond, which would explain why their significance – that they could only have been runway edge lights – was not appreciated by the flight crew.

Aeronautical information

Authoritative information in respect of aerodromes is contained in national AIPs. The process of distilling that information and presenting it to crews in a usable format is not regulated, although LOAs provide a level of assurance that the process is sound. This accident shows, however, that information considered important by the aerodrome authority, and therefore included in the AIP, might not always be presented on an aerodrome chart following the inevitable editorial process. Editorial decisions, although guided by company standards, nevertheless involve individual judgments as to whether a piece of information will be included or excluded. In this case, the missing information became a latent weakness in the aerodrome operator's attempt – through its AIP entry – to ensure pilots lined up correctly, and contributed to the crew's loss of situational awareness.

Runway edge lighting

Factors associated with this accident that are in common with many of the previous events reviewed include visibility, ORPs (or other expanses of hard surfaces to the side of the runway) and the lead-in from the taxiways.

The dominant common factor between this accident and other misaligned takeoffs is that a visually compelling line of edge lights was visible to the crew and was assumed to be centreline lighting. There is nothing inherent in an individual edge light that distinguishes it from a centreline light when viewed along the axis of the bi-directional element. It is the pattern of edge lights, and the relationship of this pattern to the pattern of other lights and to other visual cues, which identifies them as edge lights. If this complex relationship becomes disrupted or misinterpreted, perhaps for the reasons highlighted in the ATSB report, pilots can lose situational awareness. If individual edge lights could be identified as such directly, rather than through a process of interpretation, a crew would notice their error more easily should they line up for takeoff incorrectly. Modern lighting technology offers more options to identify lights directly than does the tungsten lighting technology on which the current standards are based. Global aerodrome lighting standards are, in general, derived from ICAO Annex 14, Volume 1, '*Aerodrome Design and Operations*'. Therefore the following Safety Recommendation is made:

Safety Recommendation 2015-038

It is recommended that the International Civil Aviation Organisation initiate the process to develop within Annex 14 Volume 1, '*Aerodrome Design and Operations'*, a standard for runway edge lights that would allow pilots to identify them specifically, without reference to other lights or other airfield features.