ACCIDENT

Aircraft Type and Registration:	Embraer EMB-505 Phenom 300, HZ-IBN
No & Type of Engines:	2 Pratt & Whitney Canada PW535E turbofan engines
Year of Manufacture:	2010 (Serial no: 50500040)
Date & Time (UTC):	31 July 2015 at 1408 hrs
Location:	Blackbushe Airport, Surrey
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - 1 (Fatal) Passengers - 3 (Fatal)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	11,000 hours (of which 1,181 were on type) Last 90 days - 23 hours Last 28 days - 5 hours
Information Source:	AAIB Field Investigation

Synopsis

At the end of a routine flight, the aircraft entered the visual circuit to land on Runway 25 at Blackbushe. A number of TCAS alerts occurred while flying in the circuit, and the pilot manoeuvred the aircraft until it was significantly higher and faster than normal for a visual approach. Following several TAWS alerts, the aircraft crossed the runway threshold 43 kt above the target threshold speed[1].

The aircraft floated before touching down and overran the runway end. It collided with an earth bank, and then cars in a car park, causing the wing to separate and a fire to start. The four occupants were fatally injured.

Several factors combined to create a very high workload for the pilot. This may have saturated his mental capacity, impeding his ability to handle new information and adapt his mental model, leading him to become fixated on continuing the approach.

History of the flight

The aircraft (Figure 1) had positioned to Milan earlier in the day, flown by the same pilot, and was returning to Blackbushe with the pilot and three passengers on board. After descending through the London Terminal Manoeuvring Area (TMA) it was handed over from London

Footnote

1 The aircraft manufacturer refers to this as '*reference speed* (V_{REF})'.

Control to Farnborough Approach. Its descent continued towards Blackbushe and, having reported that he had the airfield in sight, the pilot was instructed to descend at his own discretion. When the aircraft was approximately four miles south of its destination, he was instructed to contact Blackbushe Information.

The weather at Blackbushe was fine with light and variable winds, visibility in excess of ten kilometres, and no low cloud.

Figure 1

HZ-IBN on approach to Runway 25 shortly before the accident
(photograph taken by Geoff Pierce)

HZ-IBN entered the left-hand circuit for Runway 25 via the crosswind leg. Towards the end of the downwind leg, it overtook an Ikarus C42 microlight aircraft, climbing to pass ahead of and above that aircraft. As the climb began, at approximately 1,000 ft aal, the TCAS of HZ-IBN generated a 'DESCEND' RA alert to resolve a conflict with the microlight. The TCAS RA changed to 'MAINTAIN VERTICAL SPEED' and then 'ADJUST VERTICAL SPEED', possibly to resolve a second conflict with a light aircraft which was above HZ-IBN and to the east of the aerodrome. Neither the microlight nor the light aircraft was equipped with TCAS.

Following this climb, HZ-IBN then flew a curving base leg, descending at up to 3,000 feet per minute towards the threshold of Runway 25. The aircraft's TCAS annunciated 'CLEAR OF CONFLICT' when HZ-IBN was 1.1 nm from the runway threshold, at 1,200 ft aal, and at a speed of 146 KIAS, with the landing gear down and flap 3 selected.

The aircraft continued its approach at approximately 150 KIAS. Between 1,200 and 500 ft aal the rate of descent averaged approximately 3,000 fpm, and at 500 ft aal the descent rate was 2,500 fpm. The aircraft's TAWS generated six 'PULL UP' warnings on final approach. The aircraft crossed the Runway 25 threshold at approximately 50 ft aal at 151 KIAS. The aircraft manufacturer calculated that the appropriate target threshold speed for the aircraft's mass and configuration was 108 KIAS. The AFISO initiated a full emergency as the aircraft touched down, because "it was clear at this time that the aircraft was not going to stop".

Tyre marks made by the aircraft at touchdown indicated that it landed 710 m beyond the Runway 25 threshold. The Runway 25 declared Landing Distance Available (LDA) was 1,059 m; therefore the aircraft touched down 349 m before the end of the declared LDA. The paved runway surface extended 89 m beyond the end of the LDA.

The aircraft continued along the runway, decelerating, but departed the end of the paved surface at a groundspeed of 83 kt (84 KIAS airspeed) and struck an earth bank, which caused the aircraft to become airborne again. It then struck cars in a car park, part of a large commercial site adjacent to the aerodrome. The wing separated from the fuselage, and the fuselage rolled left through 350° before coming to rest on top of the detached wing, on a heading of 064°(M), 30° right side down and in an approximately level pitch attitude. A fire broke out in the underside of the aft fuselage and burned with increasing intensity.

The aerodrome's RFFS responded to the crash alarm but their path to the accident site was blocked by a locked gate between the aerodrome and commercial site. The first two RFFS vehicles arrived at the gate 1 minute and 34 seconds after the aircraft left the runway end. The third RFFS vehicle, which carried a key for the gate, arrived approximately one minute later, and the three RFFS vehicles proceeded through the gate 2 minutes and 46 seconds after the aircraft left the runway. As the aircraft was located in an area of the car park surrounded by a 2.4 m tall wire mesh fence, the RFFS vehicles had to drive approximately 400 m to gain access to the accident site. Despite applying all their available media, the RFFS was unable to bring the fire under control. The intensity of the fire meant that it was not possible to approach the aircraft to save life.

All four occupants of the aircraft survived the impact and subsequently died from the effects of fire.

Subsequently, local authority fire appliances arrived and the fire was extinguished.

Meteorological information

The weather at Blackbushe was fine with no low cloud, visibility in excess of 10 km, and light winds. The sun was in the south-west at an elevation of 50°. There was no precipitation and the runway was dry. The QNH was 1017 hPa and the temperature 21°C.

Between 1334 and 1407 hrs, the Aerodrome Flight Information Service Officer (AFISO) provided 11 wind reports to aircraft; these all stated that the wind was light and variable, except one report at 1345 hrs, stating the wind was 280/5 kt and one at 1358 hrs, stating 280/6 kt.

Personnel information

The pilot of HZ-IBN had been employed by the aircraft operator as a single-pilot Phenom 300 Captain since 2011. He held an Airline Transport Pilot certificate and first class medical certificate issued by the Kingdom of Saudi Arabia General Authority of Civil Aviation (GACA). His initial and recurrent training on the Phenom 300, consisting of ground school and simulator exercises, had been conducted by a third-party training provider. His last evaluation was a proficiency check, which he passed, carried out in a Phenom 300 simulator by a GACA-accredited examiner on 4 June 2015. Prior to his employment with the operator of HZ-IBN, he had worked as a flight instructor, and then was employed as a Cessna 560XLS pilot and check airman; he had also flown the Airbus A320 for a year in an airline operation.

He took two weeks annual leave and returned to duty on 30 July, flying as an airline passenger to London then travelling to a hotel near Farnborough where he stayed overnight. On the morning of 31 July, he travelled to Blackbushe to operate HZ-IBN. His family reported that he was in good health both mentally and physically before he left for Farnborough.

Aerodrome information

Blackbushe Airport (Figure 2) ATZ (Aerodrome Traffic Zone) abuts the Farnborough ATZ, and the demarcation between the two follows the M3 motorway, which is clearly visible from the air. The ATZ extends from the surface to 2,000 ft aal, which is 2,325 ft amsl. There are several noise-sensitive areas around the aerodrome, which pilots are asked to avoid.

Figure 2

Extract of UK CAA 1:500,000 aeronautical chart showing Blackbushe Airport and its surroundings

The aerodrome has one asphalt runway (Figure 3), orientated 07/25, measuring 1,335 by 46 m. The landing distance available on Runway 25 is 1,059 m, beginning at the threshold and ending at an unmarked point 89 m before the end of the asphalt surface. The Runway 25 threshold elevation is 324 ft and the runway has no appreciable slope. At the western end of the runway there is an earth bank one metre high, partially covered in low vegetation, beyond which a wire mesh fence separates the aerodrome from the car park.

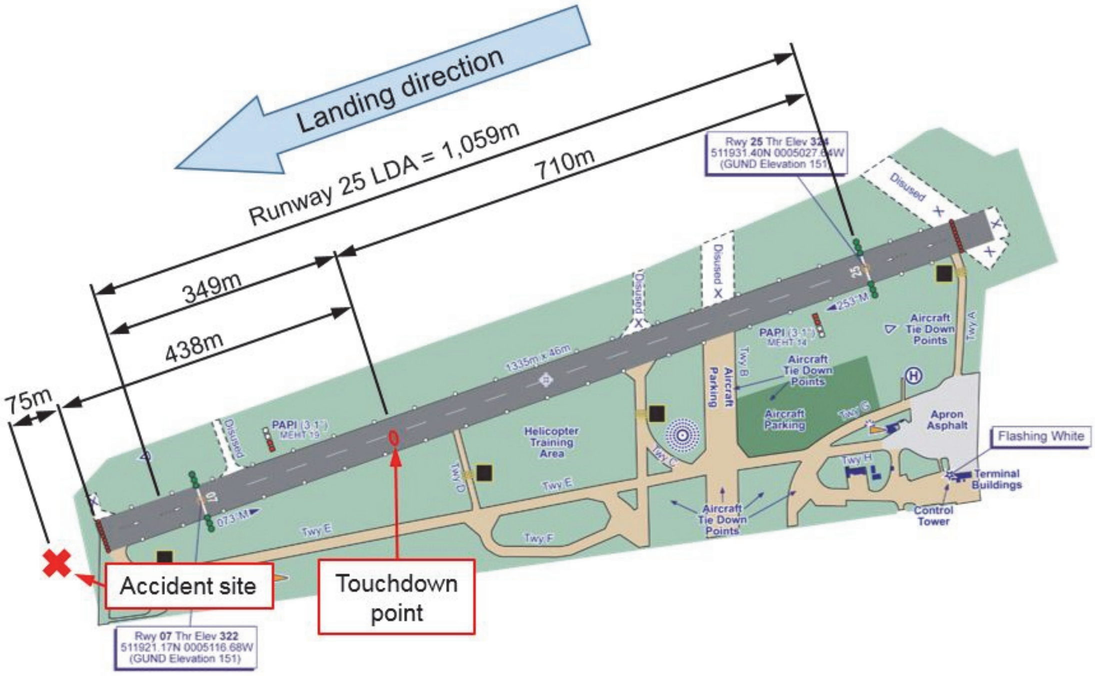

Figure 3

Blackbushe aerodrome chart, showing LDA and approximate touchdown point

On larger runways, regulations stipulate that there must be a Runway End Safety Area (RESA), but this requirement did not apply at Blackbushe and the presence of the earth bank was permissible.

There are no published instrument approach procedures at the aerodrome.

The UK Integrated Aeronautical Information Package (IAIP) states that by day circuits are to be flown south of the aerodrome, stipulates circuit heights of 800 ft aal for *'light single-engined aircraft'* and 1,200 ft aal for *'twin-engined and executive aircraft'*, and provides the following information concerning missed approaches:

> *Missed Approaches*
>
> *(a) In the event of an aircraft carrying out a Missed Approach, pilots are requested where able, to carry out a visual circuit (south side of the Runway) AND remain within the Blackbushe ATZ North of the M3.*
>
> *(b) Pilots must remain aware of the close proximity of instrument approach procedures to Farnborough, and the likelihood of traffic confliction as a result.*
>
> *(c) Where remaining within the Blackbushe ATZ is not possible, the following Missed Approach tracks/altitudes are recommended to deconflict against IFR operations into/out of Farnborough. Note these have not been assessed for terrain clearance, and pilots must ensure they adhere to their own terrain clearance requirements, remain outside of Controlled Airspace, and maintain a good lookout within Class G airspace for other aircraft in the vicinity.*

(d) Farnborough radar may offer traffic information and guidance on repositioning during its hours of operation.

(ii) Runway 25

(1) Climb straight ahead until passing BLC D2.0 or 1,500 ft QNH (whichever is sooner) then turn right on track to the west, maintain VMC (if possible) and climb to altitude 2,400 ft. Retain last assigned SSR code and contact Farnborough Radar frequency 134.350 MHz.

(2) If 2 way contact cannot be established with Farnborough Radar, aircraft should either attempt a further approach to Blackbushe, or divert remaining outside of Controlled Airspace as appropriate.

(3) Pilots should note the Farnborough ATZ is notified as active H24.

These instructions were reproduced in the briefing material provided to the pilot of HZ-IBN.

Communications

Blackbushe

Blackbushe Airport routinely provides a Flight Information Service staffed by AFISOs in the visual control room, which is situated at the top of a tower on the western side of the main aerodrome building.

AFISOs and some pilots agreed that in suitable traffic conditions, base leg joins appeared effective for relatively faster aircraft arriving at Blackbushe, because such aircraft did not have to give way to or overtake slower aircraft in the circuit.

The Manual of Flight Information Services, CAP797, defined a FIS as follows:

Flight Information Service (FIS)

A FIS, as defined by ICAO, is a service provided for the purpose of giving advice and information useful for the safe and efficient conduct of flight, together with pertinent information about:

a) weather;

b) changes to serviceability of facilities;

c) conditions at aerodromes;

d) any other information likely to affect safety.

The first two paragraphs stating a FISO's responsibility were as follows:

> **Responsibility**
>
> 1.1 FISOs may issue advice and shall issue information to aircraft in their area of responsibility, useful for the safe and efficient conduct of flights.
>
> 1.2 FISOs are not permitted to issue instructions, except for those circumstances in paragraph 1.3, or when relaying a clearance from an air traffic control unit. Pilots therefore are wholly responsible for collision avoidance in conformity with the Rules of the Air.

Paragraph 1.3 dealt with manoeuvring on the ground.

Section 8 of CAP797 dealt with Flight Information Service at Aerodromes and included the following pertinent paragraphs:

> **Introduction**
>
> 8.1 AFIS is the term used to describe the provision of advice and information useful for the safe and efficient conduct of aerodrome traffic, including assisting pilots in the prevention of collisions.
>
> 8.2 An AFIS unit provides AFIS to traffic operating within, and in the vicinity of the Aerodrome Traffic Zone (ATZ). Additionally an AFISO may provide a Basic Service to other aircraft upon request.
>
> 8.3 Due to the limits of their licence, AFISOs shall not enter into agreements with pilots on a short term tactical basis when providing a basic service.

And:

> 8.89 To facilitate the integration of arriving aircraft with existing circuit traffic, in addition to the provision of traffic information, AFISOs may provide advice on the published aerodrome joining procedures and/or a suggested course of action to the traffic situation.

Farnborough

The ANSP at Farnborough provided approach radar services to HZ-IBN. The controller who dealt with the aircraft was under training by a qualified On-the-Job Training Instructor (OJTI). Workload at the time was assessed as "medium-high". This, and the absence of an Air Traffic Services Assistant (ATSA) on duty because of sickness, meant that a ten-mile check (see below) was not provided to the AFISO at Blackbushe. There was no requirement to provide a ten-mile check.

AFISO's recollections

The AFISO on duty stated that "Farnborough ATC had passed me a Goodwood[2] estimate for [HZ-IBN] but they didn't talk to me again and didn't pass a message when the aircraft was ten miles away as they normally do. This allows us to discuss the traffic situation and aircraft will sometimes join on left base as a result". He added that "All of the approaches and departures that I have previously witnessed by this aircraft and by this pilot have seemed normal".

The operator of HZ-IBN

HZ-IBN was operated privately for its owner by a company based in the Kingdom of Saudi Arabia. Although it was a private operation, not required by regulation to operate to the same documentation requirements of a commercial operator, the company had several features of a commercial transport undertaking, including an operations manual and standard operating procedures. The operator's fleet included one other Phenom 300, which the pilot of HZ-IBN also flew.

The operator's two Phenom 300s had visited Blackbushe a total of 35 times since August 2014, HZ-IBN on 27 of those, and the pilot had operated into Blackbushe 15 times, most recently in March 2015.

Although the company regularly undertook operations to Blackbushe, most of the destinations to which the Phenom 300 aircraft flew were large international airports in Europe and the Middle East. Analysis of FDR data for both Phenoms showed that visual circuit arrivals were rare and seldom occurred other than at Blackbushe.

A commercially-produced aerodrome guide including instrument procedures was provided to Phenom 300 pilots, both integrated into the aircraft's avionics and on a tablet computer used in the cockpit.

The pilot of HZ-IBN had received training from the operator that included discussion of landing overruns, speed control, contaminated runways and the brake-by-wire system fitted to the Phenom 300. Although the operator had a flight data monitoring scheme on other aircraft types, no such scheme was in place on its Phenom 300s.

The operator had the following stable approach criteria:

> ***4.10.2 Stabilized Approach Policy***
>
> *Operational experience has proven that a stabilized approach is essential for safe operations of all aircraft. Configuration changes at low altitude are limited to those changes that can be easily accommodated without adversely affecting pilot workload. A stabilized approach means that the aircraft must be in an approved landing configuration, must maintain the proper approach speed*

Footnote

2 Goodwood VOR, 28 nm south of Blackbushe, on HZ-IBN's inbound route.

and must be established on the proper flight path before descending below the minimum "stabilized approach height" specified for the type of operation being conducted. These conditions must be maintained throughout the remainder of the approach for it to be considered a stabilized approach.

A stabilized approach has the following parameters:

- *The aircraft is on the correct vertical and horizontal flight path. Correct flight path means the path to the correct airport, runway and approach procedure; flying the correct profile as depicted in the approved and current approach chart;*
- *The aircraft is in the desired configuration for approach or landing (ie. flap setting);*
- *Descent rate is no greater than 1,000 fpm; if an approach requires a sink rate greater than 1,000 fpm, a special briefing should be included;*
- *Power settings are appropriate for the aircraft configuration and are not below minimum power for approach as defined by the AFM;*
- *On ILS approaches, within one dot on the localizer and glide slope;*
- *On circling approaches wings should be level on final when the aircraft reaches 300 feet above airport elevation*
- ***Prior to reaching the FAF, the visibility and celiing's for either a precision approach or non-precision approach, must be at or above the published minimum.***

If a normal landing cannot be made in the touchdown zone, a stabilized approach must be established before descending below the following minimum stabilized approach heights:

- *200 feet above airport elevation during visual approaches and straight-in instrument approaches in VMC;*
- *MDA or 200 feet above airport elevation, whichever is lower, if a circling manoeuver is to be conducted after completing an instrument approach;*
- *1,000 feet above the airport or TDZ elevation during any straight-in instrument approach in IMC.*

If a stabilized approach cannot be achieved before descending below the minimum stabilized approach heights, immediate action will be taken to execute a missed approach or go-around. Other situations leading to the initiation of a missed approach are as follows:

- *Confusion exists or ATC coordination has broken down;*
- *There is uncertainty about situational awareness;*
- *Checklists are being conducted late or the pilot is task overloaded;*
- *Any malfunction threatens the successful completion of the approach;*
- *Unexpected wind shear is encountered - proceed per company policy;*
- *ATC changes will result in an unstabilized approach.*

The operator specified that a visual circuit should be flown at 1,500 ft aal and the downwind leg should be flown 1.5 nm from the runway.

The operator's operations manual included a description of its risk management system, which included an *'Electronic Flight Risk Assessment form'* to be completed by the pilot. It provided for risks to be 'scored' and required a review of the proposed flight with the chief pilot in the event that a particular score was achieved.

The form could be completed on the tablet computer and saved for later download to the company's systems; a back-up paper form was also provided on board the company's aircraft. No form had been received by the company for the flight into Blackbushe, but it is possible that either it had been completed on the tablet computer and saved for download, or a paper copy had been completed and retained on board the aircraft. The extent of the damage to the aircraft meant that no paper material was recovered from the flight deck area and none of the electronic devices on board could be downloaded.

Other traffic

The C42 microlight, a high-wing three-axis single-engine aircraft, was being flown by a student pilot in the left seat and instructor in the right. The instructor reported that because the student had a tendency to lose height slightly while carrying out pre-landing checks downwind, he was particularly monitoring the student's height-keeping. The instructor recalled that the altimeter indicated exactly 800 ft during the downwind leg, with the QFE set[3]. The microlight's airspeed on the downwind leg was approximately 66 KIAS.

The overflying light aircraft, involved in the later TCAS RAs, was a high-wing single-engine piston aircraft on a cross-country flight. Its pilot was in receipt of a service from Farnborough Radar. Although its flight plan showed an intended altitude of 2,200 ft, the pilot flying the aircraft recalled that he had crossed the Blackbushe ATZ at 2,350 ft amsl, while the passenger in the front right seat (who was also a pilot) recalled that this portion of the flight was undertaken at 2,400 ft amsl. The altitude reported by the overflying aircraft's transponder was 2,300 ft amsl. No information was supplied to this aircraft about the traffic in the Blackbushe traffic pattern, nor was the AFISO at Blackbushe aware of the overflying aircraft.

Operations in the traffic pattern

Rules 8 and 11 of the Rules of the Air were relevant to the disposition of traffic when the microlight instructor reported that his aircraft was downwind:

> *Rule 8 Avoiding aerial collisions:*
>
> *(4) An aircraft which is obliged by this Section to give way to another aircraft shall avoid passing over or under the other aircraft, or crossing ahead of it, unless passing well clear of it.*

Footnote

[3] Equating to approximately 1,100 ft amsl.

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

Rule 11 Overtaking

(1) Subject to paragraph (3), an aircraft which is being overtaken in the air shall have the right-of-way and the overtaking aircraft, whether climbing, descending or in horizontal flight, shall keep out of the way of the other aircraft by altering course to the right.

(2) An aircraft which is overtaking another aircraft shall keep out of the way of the other aircraft until that other aircraft has been passed and is clear, notwithstanding any change in the relative positions of the two aircraft.

Recorded information

Sources of recorded information

Recorded information was available from the aircraft's combined Cockpit Voice and Flight Data Recorder (CVFDR)[4], radar, radio telephony communications, CCTV and video, and photographs taken by witnesses.

The CVFDR was recovered from the wreckage and transported to the AAIB flight recorder laboratory. Although externally damaged by high temperatures, a complete record of the accident flight was available, with 246 hours of data and just over two hours of audio. Both the data and audio records ended as the aircraft overran the end of the runway. The recording system was equipped with an impact switch that stops the CVFDR in the event of an accident.

Radar and RTF records[5] included HZ-IBN's approach and landing and other aircraft operating in and near the Blackbushe ATZ. TCAS downlink information from HZ-IBN was also recorded by radar. Altitude information for the Ikarus C42 Microlight was recorded at a resolution of 25 ft.

Figure 4 presents salient parameters from the CVFDR, starting just before the aircraft turned from downwind onto the final approach. Figure 5 presents the approach track of HZ-IBN to Blackbushe Airport. Figures 6 and 7 present the relative positions of HZ-IBN, the microlight and overflying aircraft when TCAS RA's occurred.

CCTV footage from four cameras captured HZ-IBN as it flew over the runway threshold, travelled along the runway and overran the end where it collided with parked vehicles, and the footage continued until the fire was fully extinguished. A photograph and short video, obtained from witnesses, provided a record of the aircraft's approach shortly before it touched down.

Footnote

4 The aircraft manufacturer refers to this as the 'Cockpit Voice and Data Recorder (CVDR)'.

5 Farnborough Approach 134.350 MHz and Blackbushe Information 122.300 MHz. The CVFDR recorded RTF communications to/from HZ-IBN and other aircraft on the same frequency.

Summary of recorded data

HZ-IBN took off from Milan Malpensa Airport at 1234 hrs. The climb and cruise were uneventful. As the aircraft approached Paris, the pilot tuned the VHF 2 radio to the Blackbushe Information frequency in preparation for the approach. The VHF 1 radio was tuned to the assigned ATC frequency and used as the transmitting radio until the pilot later selected to transmit on VHF 2; this configuration enabled the pilot to listen to two VHF radio frequencies at the same time. Nothing recorded on the CVR suggested that there was a second person in the cockpit.

At 1336 hrs the aircraft was transferred to London Area Control (LAC) which provided descent clearances and routing information to Blackbushe. As the aircraft approached the south coast of England, the pilot spoke with the Blackbushe AFISO to advise that he anticipated being released from LAC in about 15 minutes and that the number of passengers was unchanged from details previously provided. He then requested the runway in use and QNH, which was provided. At 1401 hrs the pilot reported to the LAC controller that he could see Blackbushe and he was transferred to the Farnborough Radar frequency.

As HZ-IBN overflew the Farnborough ATZ, the pilot was cleared to descend at his discretion and instructed to contact Blackbushe Information. Having established contact with the AFISO the pilot advised he would be "COMING ON OVERHEAD THE AIRPORT AND I WILL BE TURNING DOWNWIND SOON FOR RUNWAY TWO FIVE MAINTAINING TWO THOUSAND FEET". The AFISO enquired whether the aircraft was arriving from the south to which the pilot replied in the affirmative, adding that he was "JUST COMING OVERHEAD THE TOWER I'LL BE TURNING IN TOWARD ERR THE DOWNWIND VERY SOON" and that he could see an aircraft (a microlight being flown by an instructor and student) climbing from the runway. The pilot of HZ-IBN queried at what altitude the microlight would be operating, saying "AND HE IS MAINTAINING TWENTY ER FIFTEEN HUNDRED CONFIRM" to which the controller replied that the aircraft was "WORKING AT ONE THOUSAND ONE HUNDRED FEET ON THE QNH". HZ-IBN's pilot then reported that he was "MAINTAINING TWO THOUSAND FEET ON THE QNH AND I'LL BE TURNING (PAUSE) BASE IN JUST LESS THAN A MINUTE SIR".

When HZ-IBN was just south of the aerodrome overhead, its TCAS presented a Traffic Advisory (TA) message to the pilot. This had been triggered by the microlight, which was turning onto the crosswind leg at 1,100 ft amsl. The microlight instructor then advised that he was visual with HZ-IBN.

HZ-IBN entered the upwind leg of the circuit over the upwind end of Runway 25 at 1,900 ft amsl at 173 KIAS in clean configuration before turning onto the crosswind leg. The pilot reported "TURNING BASE NOW AND WE SHOULD BE TAKING DOWNWIND IN LESS THAN ONE MINUTE". The AFISO advised the pilot of HZ-IBN that the microlight was ahead of him; the pilot confirmed that he had the microlight in sight and would "MAINTAIN TWO THOUSAND FEET ALL THE WAY".

A short time later, the microlight instructor reported that he was downwind for a touch-and-go, to which the AFISO replied "[MICROLIGHT'S ABBREVIATED CALLSIGN] ROGER I'M NOT SURE HOW THIS IS GOING TO WORK [MICROLIGHT INSTRUCTOR'S FORENAME]". The instructor aboard the microlight took this to be a reference to the sequencing of the two aircraft onto the final approach and replied "ER [AFISO'S FIRST NAME] WE'LL EXTEND ON DOWNWIND TO LET THE JET IN [BRIEF PAUSE] JET IN FIRST IF YOU'RE HAPPY WITH THAT". The AFISO responded "THAT MIGHT WORK" before asking the pilot of HZ-IBN "DID YOU COPY THAT" to which the pilot replied "I COPY THAT I WAS DOING THE SAME FOR HIM BUT IN THIS IS THE CASE I'LL JUST ER DESCEND AND DO MY LANDING". The AFISO reiterated that the microlight would extend to enable HZ-IBN to be number one, and the pilot of HZ-IBN acknowledged this.

The microlight was now established on a downwind track laterally displaced 0.9 nm from the runway and HZ-IBN was displaced about 1.6 nm from the runway (Figure 6). Throughout this period several cockpit alerts and announcements were recorded on the CVR, with up to three sounds from different sources occurring simultaneously (ie RTF communications and aircraft systems such as TCAS and TAWS).

HZ-IBN then started to descend and the landing gear was lowered. As the aircraft passed abeam the threshold of Runway 25, the autopilot was disconnected, triggering an automatic "AUTOPILOT" announcement which occurred four times, and the pilot started to make a left turn onto the final approach, reporting as he did so "AND HOTEL ZULU INDIA BRAVO NOVEMBER TURNING FINAL ERR TURNING [PAUSE] CROSSING DOWN TO THE FINAL FOR RUNWAY TWO FIVE"; HZ-IBN was at an altitude of 1,570 ft and an airspeed of 164 KIAS.

As the AFISO acknowledged this transmission, the pilot selected flap 1, and a TCAS TA (aural: "TRAFFIC, TRAFFIC") was presented; there was also a transmission on the Farnborough frequency between ATC and another aircraft at this time. The separation between the microlight and HZ-IBN was 1,200 m laterally, with HZ-IBN at 1,330 ft amsl and descending at about 600 fpm, and the microlight at approximately 1,270 ft amsl and climbing at about 180 fpm. The pilot of HZ-IBN then arrested the rate of descent and pitched to a climbing attitude. Flap 2 was selected, and almost simultaneously a TCAS 'descend' RA (aural instruction: "DESCEND, DESCEND") was generated because of the detected conflict with the microlight (Figure 6). Both aircraft were at an altitude of about 1,280 ft. The pilot of HZ-IBN rapidly advanced the thrust levers fully forward, and the aircraft climbed at 2,000 fpm. The microlight was not equipped with TCAS, so there was no coordination of the RA between the two aircraft and the microlight crew were not aware of the TCAS alert. The pilot of HZ-IBN did not report the TCAS event.

Nine seconds later, the TCAS RA changed to 'MAINTAIN VERTICAL SPEED'. A few seconds later, HZ-IBN passed 320 ft above and 300 m in front of the microlight. The pilot retarded the thrust levers to the idle position. This was followed by two TCAS 'adjust vertical speed' RAs (aural instruction: "ADJUST VERTICAL SPEED, ADJUST"), which were probably in response to both the microlight and another aircraft that was on a southerly track maintaining about 2,300 ft amsl and 1.4 nm to the north of HZ-IBN (Figure 7). The pilot then started to arrest the climb whilst continuing the left turn towards the final approach. The aircraft was 1.4 nm from the runway threshold at 1,740 ft amsl and an airspeed of 137 KIAS. Shortly after, flap 3 was selected and a few second later a TCAS "CLEAR OF CONFLICT" announcement was presented. The aircraft was now 1.1 nm from the runway threshold.

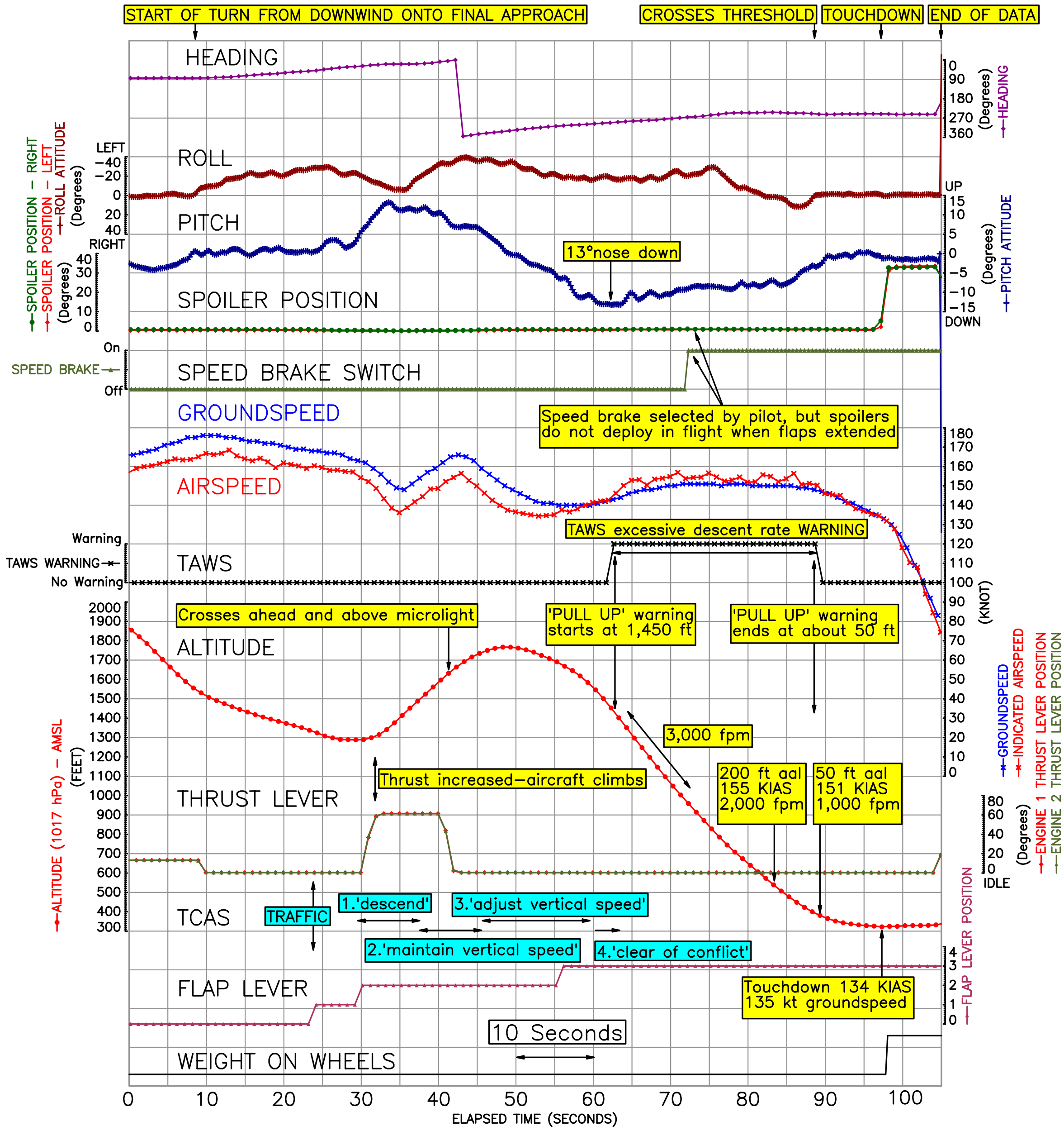

Figure 4

CVFDR data of approach

As HZ-IBN continued its approach the rate of descent increased to about 3,000 fpm and the airspeed stabilised at about 153 KIAS, with the pitch attitude reaching 13° nose-down. At 1,450 ft amsl (1,125 ft aal), the first of six TAWS excessive descent rate warnings occurred, which provided an aural "PULL UP" warning in the cockpit. At 675 ft aal the pilot selected the speed brakes out; however, they remained retracted because they are inhibited from deploying when the flaps are extended. As the aircraft descended through 500 ft aal the TAWS issued a "FIVE HUNDRED" automated announcement; the aircraft's airspeed was 156 KIAS and the rate of descent was about 2,500 fpm. At 200 ft aal the airspeed was 155 KIAS and the rate of descent was 2,000 fpm. During this period the controller advised the runway was clear for landing; no response to this transmission was recorded.

The approach continued and the aircraft crossed the threshold at about 50 ft aal at an airspeed of 151 KIAS with a rate of descent of about 1,000 fpm but reducing. This coincided with the sixth (and final) TAWS warning. The aircraft touched down about nine seconds later at an airspeed of 134 KIAS and a groundspeed of 135 kt. The ground spoilers deployed and the brakes were applied almost immediately. The aircraft decelerated at an average longitudinal deceleration of -0.45g (Figure 11). When the aircraft reached the end of the paved surface of the runway its groundspeed was 83 kt and its airspeed was 84 KIAS. In the second before the end of the CVFDR data, both thrust levers were recorded as having been advanced from the idle position and the spoilers had started to close.

The operator estimated that the landing weight was 6,522 kg. The aircraft manufacturer calculated that at this weight the target threshold speed was 108 KIAS.

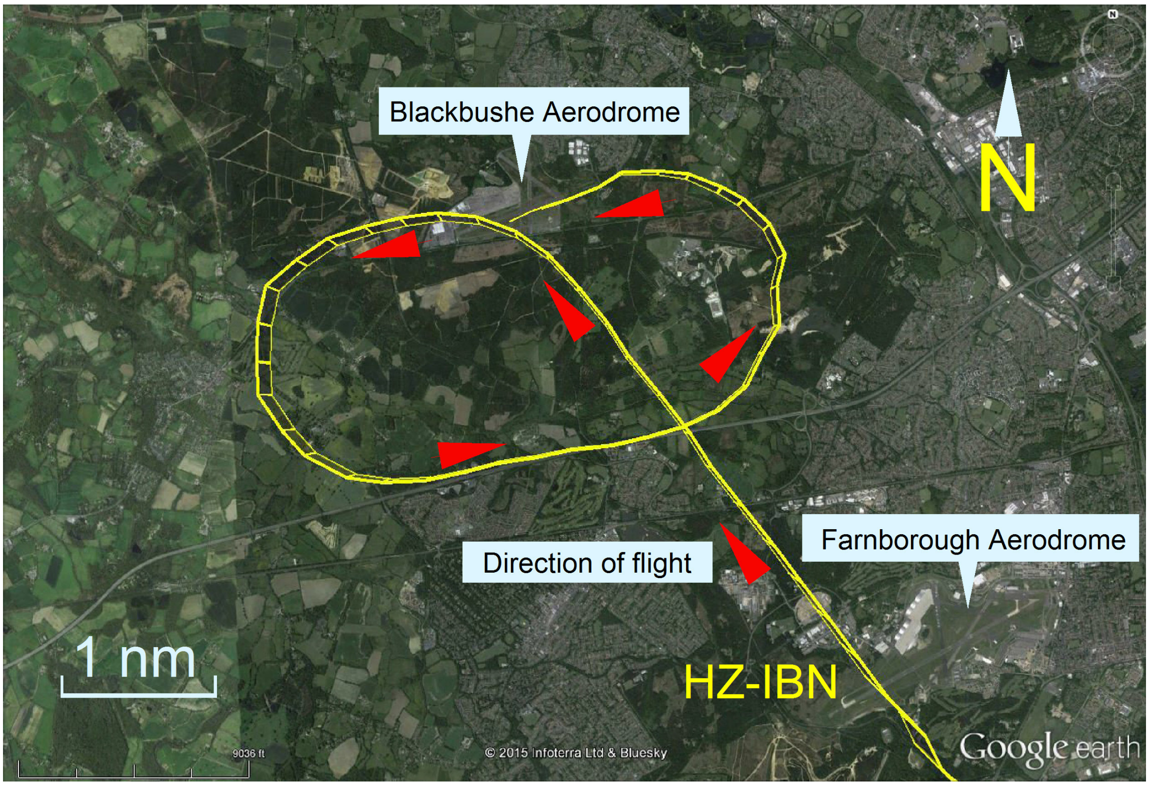

Figure 5
Approach path of HZ-IBN (Bovingdon radar)

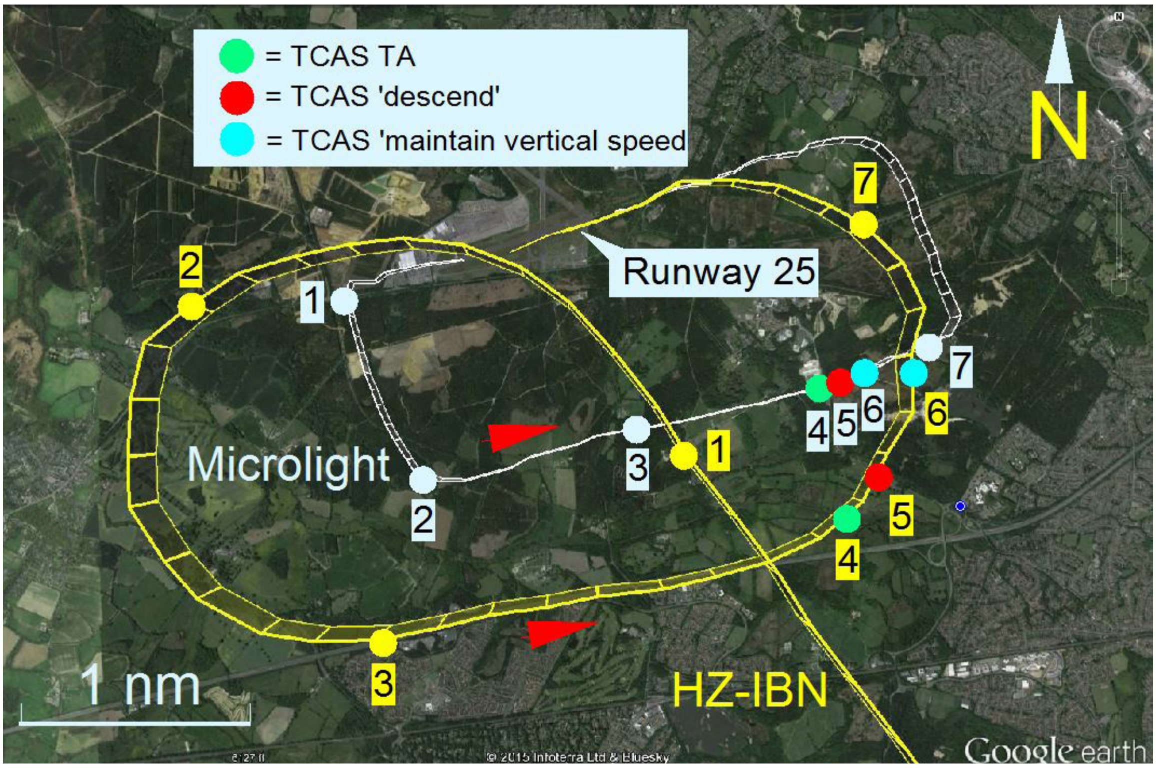

Figure 6

Relative positions of HZ-IBN and microlight
(Paired numbers and colour codes indicate relative positions of the aircraft when the TCAS alerts were generated on HZ-IBN – the other aircraft were not TCAS equipped)

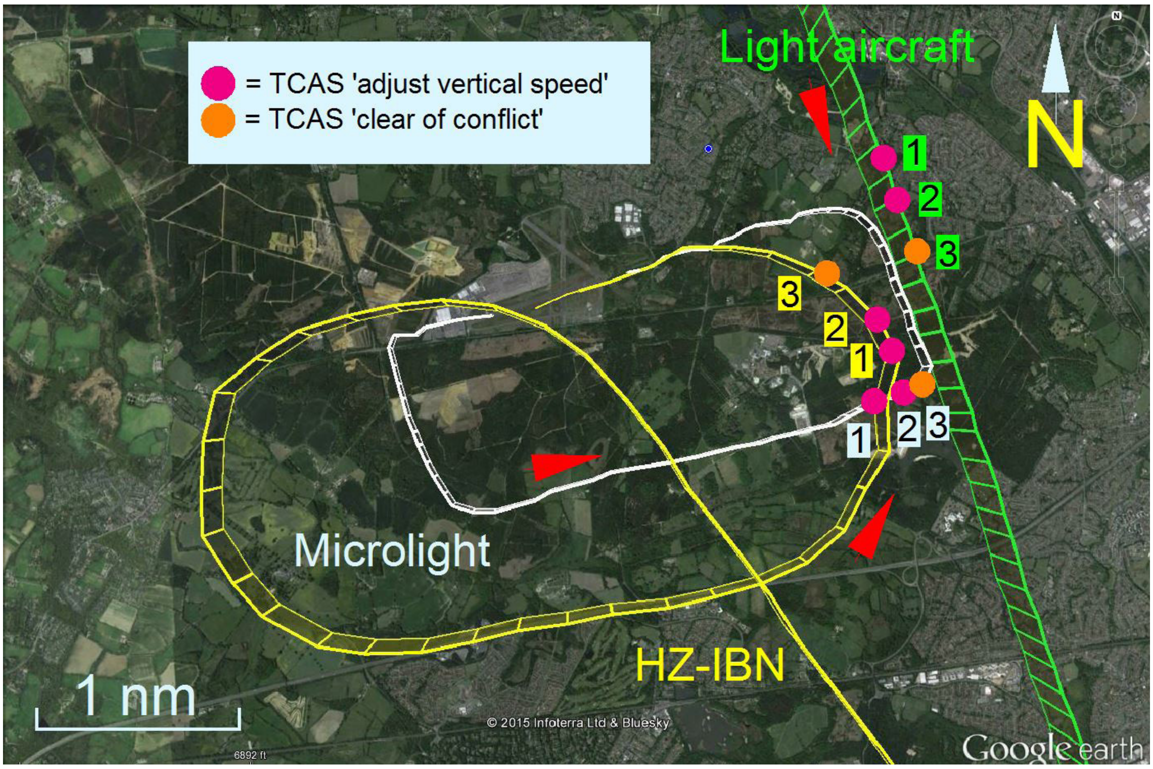

Figure 7

Relative positions of HZ-IBN, microlight and light aircraft
(Paired numbers and colour codes indicate relative positions of the aircraft when the TCAS alerts were generated on HZ-IBN – the other aircraft were not TCAS equipped)

The aural environment during the final minutes of the flight

The AAIB analysed the 3 minutes and 32 seconds from the moment the aircraft entered the Blackbushe ATZ until it passed over the threshold. Aside from environmental noise such as that produced by the engines and airflow around the aircraft, these included:

Events	From entering ATZ to end of downwind leg (2 mins 19 secs)	From end of downwind leg to threshold (1 min 13 secs)
Transmissions made by the pilot of HZ-IBN	8	1
Other transmissions on the Blackbushe frequency	13	6
Transmissions on the Farnborough Frequency (recorded on the HZ-IBN CVR)	8	8
TCAS announcements (eg "ADJUST VERTICAL SPEED, ADJUST ")	1	6
Other automated announcements and tones (eg C-chord, "AUTOPILOT")	6	2
TAWS announcements and alerts (eg "FIVE HUNDRED")	0	7
Total	36	30

TCAS performance analysis

The performance of the TCAS II (version 7.0) system fitted to HZ-IBN was analysed on behalf of the AAIB by NATS (the UK air navigation service provider) using the Eurocontrol InCAS software tool in conjunction with the radar tracks for HZ-IBN, the microlight and light aircraft. The TCAS downlink information from HZ-IBN was also referenced.

The analysis confirmed that the TCAS system operated correctly, with RA's and relative timings consistent with those recorded on the CVFDR. The "DESCEND" and "MAINTAIN VERTICAL SPEED" RA's were issued against the conflict with the microlight. The simulation further showed that the first "ADJUST VERTICAL SPEED" RA may have been issued due to a combination of both the microlight and the light aircraft, with the second RA 'adjust vertical speed' most likely a result of the light aircraft only.

Review of previous flights

Data from the previous 46 flights of HZ-IBN and 55 flights of the operator's other Phenom 300 aircraft was reviewed. The data extended back to March 2015. The approach phase of each flight was analysed in conjunction with the operator's stabilised approach criteria, which specified a stabilised height of 200 ft aal in visual metrological conditions (VMC) and 1,000 ft in instrument metrological conditions (IMC). As it was not practicable to determine the specific weather conditions during each approach, the data was checked against the operator's criteria at 200 ft, as all approaches should be stabilised by this point.

The operator defined a stabilised approach as follows:

> *'A stabilized approach means that the aircraft must be in an approved landing configuration, must maintain the proper approach speed and must be established on the proper flight path before descending below the minimum "stabilized approach height" specified for the type of operation being conducted. These conditions must be maintained throughout the remainder of the approach for it to be considered a stabilized approach.'*

The operator's criteria for a stabilised approach included the following:

> *'Descent rate is no greater than 1,000 fpm; if an approach requires a sink rate greater than 1,000 fpm, a special briefing should be included;*
>
> *If a stabilized approach cannot be achieved before descending below the minimum stabilized approach heights, immediate action will be taken to execute a missed approach or go-around.'*

Twenty of the examined flights were flown by the pilot of the accident flight. On 18 April 2015 he had flown HZ-IBN from Riyadh to Jeddah King Abdulaziz International Airport, landing on Runway 34L which has a landing distance of 3,800 m available. Figure 8 presents the salient parameters for this landing. There were a number of similarities between this approach and that of the accident flight, with a high rate of descent, TAWS warnings and a speed of about 150 KIAS as the aircraft crossed the threshold at a height of about 30 ft. During this landing the flaps were still extending as the aircraft touched down. Another similar approach and landing was also identified; this had been flown by a different pilot landing at a different airport in Saudi Arabia. The operator stated that it was unaware of either of these events prior to the accident.

The remaining flights for the pilot of the accident flight were all found to be stabilised by 200 ft aal.

On previous flights into Blackbushe, the operator's Phenom aircraft had joined either on the base leg or via the overhead. No data was available for the pilot's previous flights into Blackbushe.

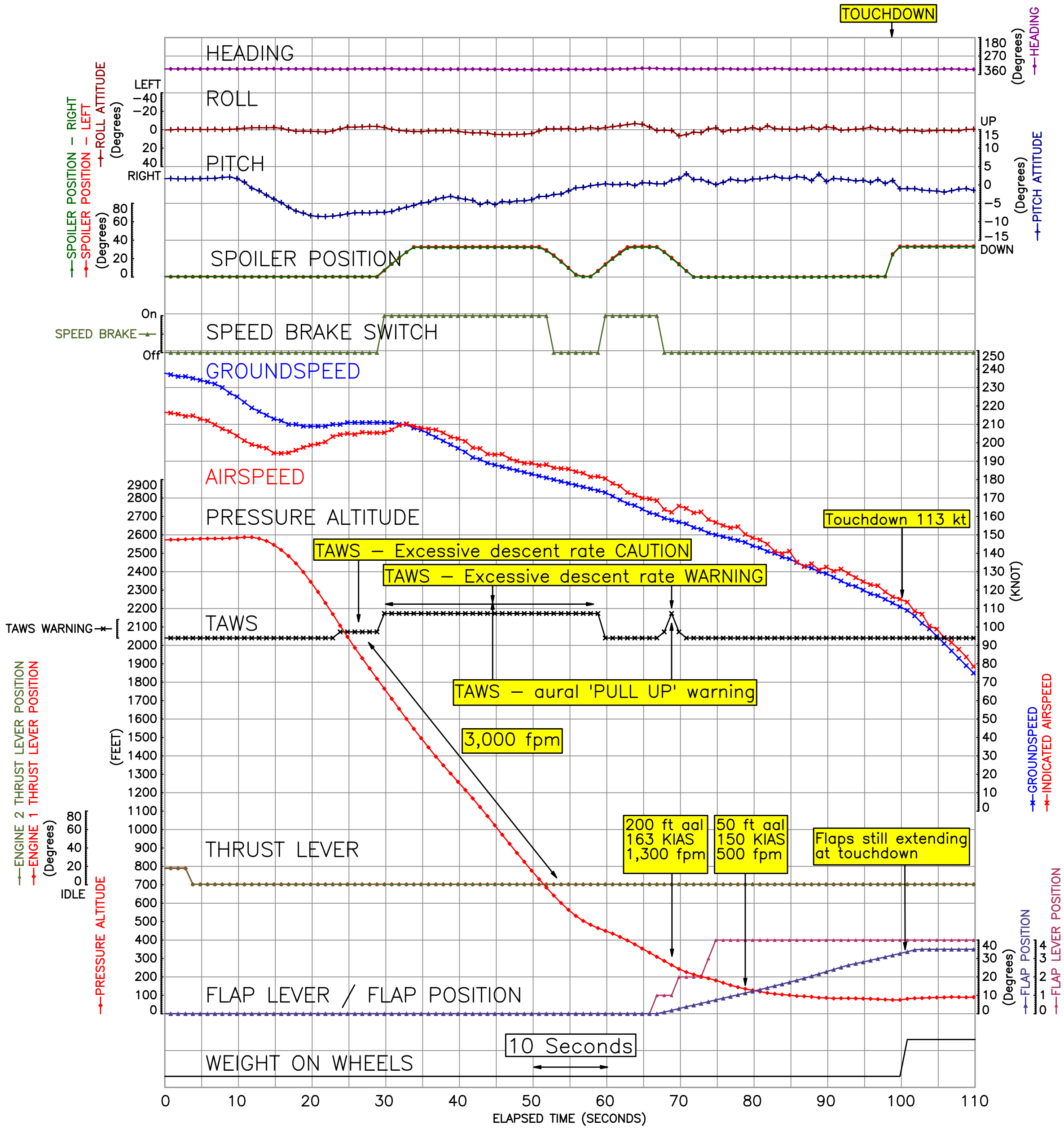

Figure 8

Pilot of HZ-IBN landing at Jeddah 18 April 2015

Aircraft information

The Embraer EMB-505 Phenom 300 aircraft is a swept-wing business jet, powered by two rear-mounted turbofan engines. The maximum takeoff mass is 8,150 kg and the maximum landing mass is 7,650 kg[6]. The aircraft is approved for both two pilot and single pilot operations. The pressurised fuselage cabin contains seating for up to nine passengers, although HZ-IBN was configured with seven passenger seats (Figure 9). The aircraft's single-piece wing is attached to the bottom of the fuselage and contains integral fuel tanks, with fuel supply lines running from the left and right wings to the left and right engines respectively.

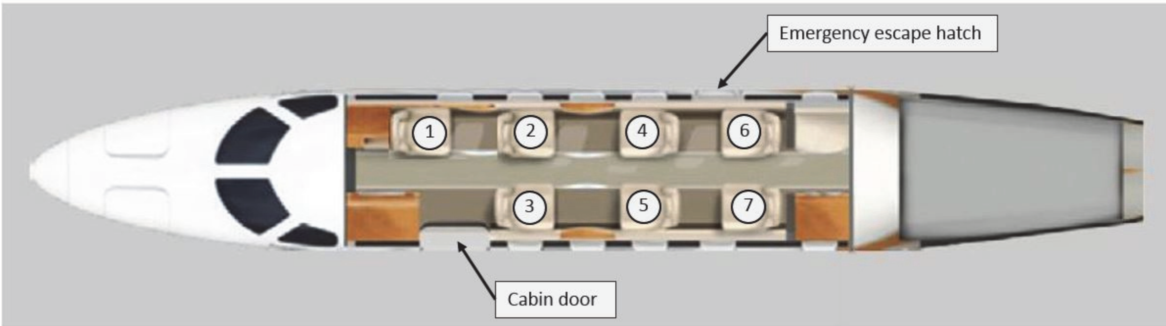

Figure courtesy of Embraer

Figure 9

HZ-IBN cabin layout

HZ-IBN was manufactured in 2010 and had accumulated 2,409.2 flight hours and 1,377 flight cycles in operation prior to the accident flight. The aircraft's annually-expiring Certificate of Airworthiness was renewed on 8 April 2015 and the last scheduled maintenance inspection occurred on 28 July 2015 at a maintenance facility at Stansted Airport. This scheduled inspection involved functional checks of the aircraft's two main batteries and two emergency batteries, as required by the aircraft's approved maintenance programme.

Whilst the aircraft underwent this scheduled maintenance, the operator requested that a number of aircraft defects were also rectified. These defects included reported faults with the aircraft's weather radar, #1 GPS antenna, aft cargo door warning system and lavatory. All these defects were rectified and the aircraft had no further defects recorded in the technical log or deferred defects log, prior to the accident flight.

The aircraft's technical records were examined which showed that all life limited components installed on the aircraft were within their permitted service lives at the time of the accident and all Airworthiness Directives applicable to the aircraft had been complied with.

Footnote

6 Optional Service Bulletin SB-505-00-0008 is available which increases the MTOM to 8,340 kg and MLM to 7,730 kg. HZ-IBN did not have this Service Bulletin embodied.

Landing gear and brake system description

The Phenom 300 is equipped with a retractable single-wheeled tricycle landing gear, with braking capability on the main landing gear and steering capability on the nose landing gear. The main landing gear is of the trailing-arm type and retracts sidewards and inboard into the wing. Each gear of the main landing gear is equipped with one wheel and tyre, one brake assembly, one wheel speed transducer and two weight on wheel (WOW) sensors.

The aircraft braking system comprises the main brake system and an emergency braking system that also functions as a parking brake. The main brake system controls hydraulic fluid pressure to the brakes as a function of brake pedal displacement. An anti-skid system is provided which is designed to prevent the main tyres skidding during braking and to minimise the stopping distance. The anti-skid system modulates the brake pressure using an electrical signal from the brake control unit to the brake control valve, which controls the hydraulic pressure applied to each mainwheel brake pack. A touchdown protection system is provided which allows the mainwheels to spin-up at touchdown even if the pilot commands braking via the brake pedals prior to touchdown, to prevent tyre blow-out at touchdown. Touchdown protection is cancelled (allowing brake application) 3 seconds after the WOW sensors indicate 'on ground' or after both wheel speeds exceed 60 kt. No autobrake function is provided.

Flap system description

The flaps are selected using a lever on the centre pedestal which has five detent/gated positions: 0, 1, 2, 3 and FULL with corresponding flap positions as shown in Table 1.

Lever Position	Flaps Position	Detent/ Gated
0	0°	Detent/Stop
1	8°	Detent
2	26°	Gated/Stop
3	26°	Detent
FULL	35°	Detent/Stop

Table 1

Flap positions

Flap positions 1 and 2 are used for takeoff and positions 3 and FULL are used for landing. Flap lever positions 2 and 3 command the same amount of flap deflection. The purpose of having two different lever positions for the same flap deflection is to communicate to various aircraft systems whether the pilot is intending to take off (position 2), or intending to land (position 3). HZ-IBN had modification SB505-27-0011 embodied which meant that full flap position was available.

The flap lever controls four flap surfaces, two per wing. Each outboard flap is actuated by two electric flap actuators while each inboard flap is actuated by one electric actuator.

Spoiler system description

The aircraft has four spoiler panels, two on each wing, attached to the rear spar of the wing, in front of the outboard flaps. In each wing both spoiler panels are actuated by a single hydraulic Power Control Unit (PCU). The spoiler system has three functions:

- 'Roll spoiler' to augment roll control
- 'Speed brakes'
- 'Ground spoilers'

A two-position speed brake switch on the centre console commands all the spoilers to the OPEN or CLOSED position. Speed brake is only available under the following three conditions:

- Flaps retracted
- Airspeed ≥ 125 KIAS
- Throttle lever angle less than max cruise

The 'ground spoiler' function automatically arms when the WOW sensors indicate 'in air' for more than 10 seconds and the airspeed is valid and greater than 60 KIAS. During landing the spoiler panels automatically deploy as 'ground spoiler' when both thrust levers are set to the IDLE position and one of the following occurs:

- At least 3 of the 4 WOW sensors indicate 'on ground'.
- Both WOW sensors on the left main landing gear indicate 'on ground' and the left wheel speed sensor indicates the wheel is spinning above 50 kt.
- Both WOW sensors on the right main landing gear indicate 'on ground' and the right wheel speed sensor indicates the wheel is spinning above 50 kt.

When one of the above conditions is met all spoiler panels deploy to 35° in about 1.2 seconds. The spoiler panels remain deployed if any WOW sensor indicates 'in air' for up to 10 seconds (to cater for a bounced touchdown). The spoiler panels retract if either thrust lever is advanced above idle or the wheel speeds drop below 45 kt.

TAWS Excessive Descent Rate warning

HZ-IBN was equipped with a TAWS. During the accident approach, the Excessive Descent Rate (EDR) warning was activated. This is intended to alert the pilot through both aural and visual means that the aircraft is descending towards terrain at an excessive rate[7]. Figure 10 provides the EDR caution and warning envelopes. If the caution envelope is entered, an aural alert of "SINK RATE" is provided in the cockpit and visual captions of TERRAIN and SINK RATE appear on the PFD's and MFD respectively. If the warning envelope is entered, an aural alert of "WHOOP WHOOP PULL UP" is provided in the cockpit with visual captions of PULL UP displayed on the PFD's and MFD. If the aircraft transitions quickly from no alert, through the caution and into the warning envelope, the warning alert is given priority and the caution alert is suppressed.

Footnote

[7] The caution and warning envelopes are specified in TSO-C151b.

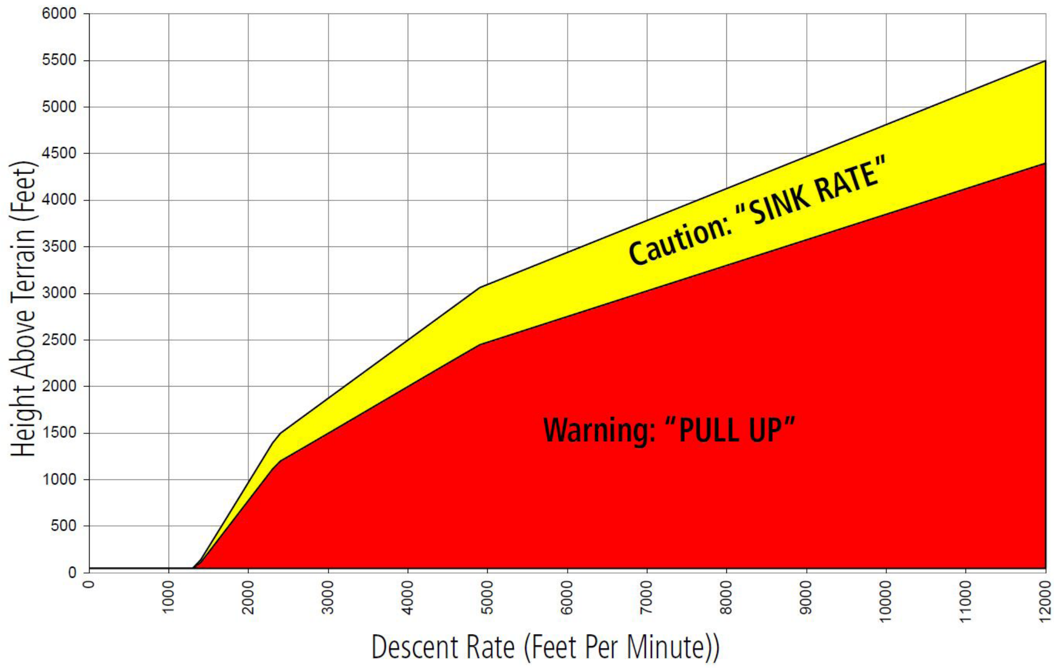

Figure 10

TAWS Excessive Descent Rate caution and warning envelopes

Landing performance

The operator estimated that the landing mass of the aircraft on the accident flight was 6,522 kg. The aircraft manufacturer was requested to model the landing performance for this landing mass and the ambient conditions prevailing at the time the accident occurred, which were:

- Zero wind
- QNH 1017 hPa
- Air temperature 21°C
- Dry asphalt runway, zero slope
- Runway elevation 324 ft amsl
- Flap 3

The manufacturer performed the landing distance calculations using the same validated performance model that is used to produce unfactored performance data as listed in the aircraft's approved flight manual. The performance model used a 1.3 second 'transition segment' between touchdown and full braking performance being achieved, and used a figure of -0.44 g for the longitudinal deceleration after touchdown which is a figure based on flight test data for a dry runway. The manufacturer calculated that for these ambient conditions the target threshold speed was 108 KIAS and the performance model predicted that the unfactored landing distance[8] would have been 731 m, with an air distance between the threshold and the touchdown point of 334 m, a touchdown speed of 105 KIAS, and a ground roll of 397 m.

Footnote

[8] The unfactored landing distance is calculated from the runway threshold with the aircraft at an initial height of 50 ft agl.

Data from the aircraft's CVFDR indicated that the aircraft crossed the threshold of Runway 25 at approximately 50 ft agl at 151 KIAS, 43 kt above the target threshold speed. The aircraft touched down 710 m beyond the Runway 25 threshold with a groundspeed at touchdown of 135 kt, and an airspeed of 134 KIAS. The performance model predicted that at this speed, the landing ground roll required to stop the aircraft would be at least 616 m[9]. Runway 25 has a declared Landing Distance Available (LDA) of 1,059 m; therefore the aircraft touched down approximately 349 m before the end of the declared LDA, 438 m before the end of the paved runway surface (Figure 3).

Braking system performance

The aircraft's deceleration, as recorded on its CVFDR, is shown in Figure 11. This data shows that, 2.7 seconds after touchdown, the aircraft maintained an average longitudinal deceleration of -0.45g until it departed the end of the runway.

Accident site

Runway tyre marks

There were three tyre tracks in the earth bank at the end of the runway, formed by the two main wheels and the nosewheel, where the aircraft departed the runway (Figure 12). There were also two rubber tyre marks on the paved surface corresponding to where the main wheels departed the runway. These rubber tyre marks could be traced back to the point where the aircraft touched down (Figure 13). At touchdown the wheel spin-up causes rubber to be deposited on the runway surface causing the dark marks from each wheel shown in Figure 13. The marks showed that the left wheel touched down first, followed by the right wheel and then the nosewheel. The left wheel touched down 438 m from the end of the paved surface, and the right wheel 4.3 m closer. There were short breaks in the initial touchdown marks which were probably the result of the wheels skipping before they settle. The brakes would not yet have activated at this point.

After an initial 21 m touchdown tyre mark from the right wheel there was a gap of 16.5 m and then there was a continuous tyre mark from the right wheel until the end of the paved surface (Figure 14). This indicates that the right wheel was under continuous braking from at least 37.5 m after touchdown until the end of the paved surface[10]. At an average ground speed of 134 kt, this represents a time interval of 0.5 seconds after right wheel touchdown. The nosewheel left a 12 m touchdown mark, but no further tyre marks because this wheel is not braked. The left wheel left a 20.5 m touchdown mark, followed by four gaps of no tyre marks in an otherwise continuous tyre mark until the end of the paved surface (Figure 14). The mark became continuous 168 m after touchdown which indicated that the left wheel achieved continuous effective braking action 168 m after touchdown. At an average ground speed of 130 kt, this represents a time interval of 2.5 seconds after left wheel touchdown.

Footnote

9 The manufacturer commented that its calculation was based on a maximum performance landing, as performed in test flights.

10 A non-skidding wheel can leave a tyre mark under heavy braking because the braked wheel is at a slower speed than the pavement surface, which results in the friction force removing a thin layer of rubber.

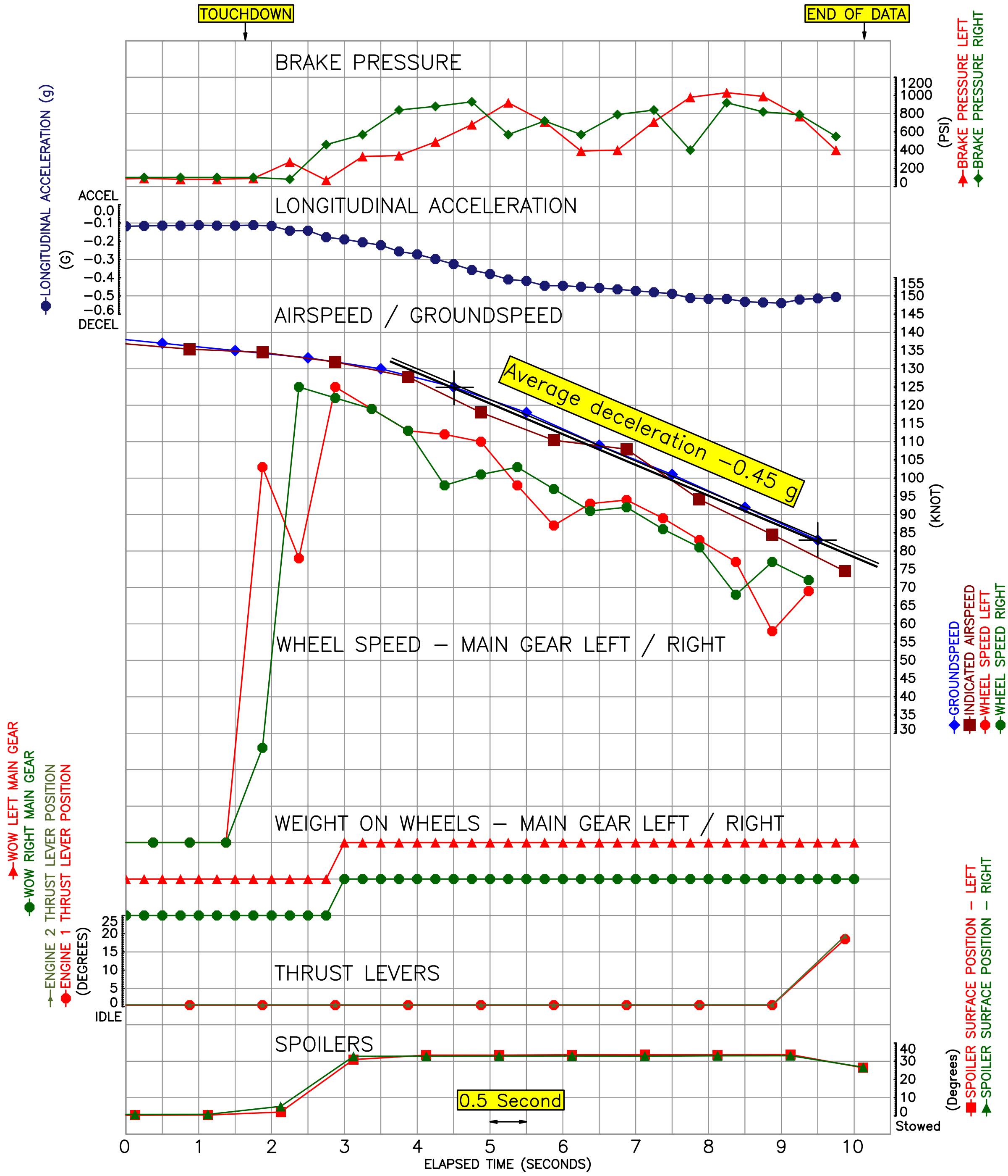

Figure 11

Braking system performance recorded by CVFDR

Figure 12

Tyre tracks from the main wheels and nosewheel in the earth bank at the end of Runway 25

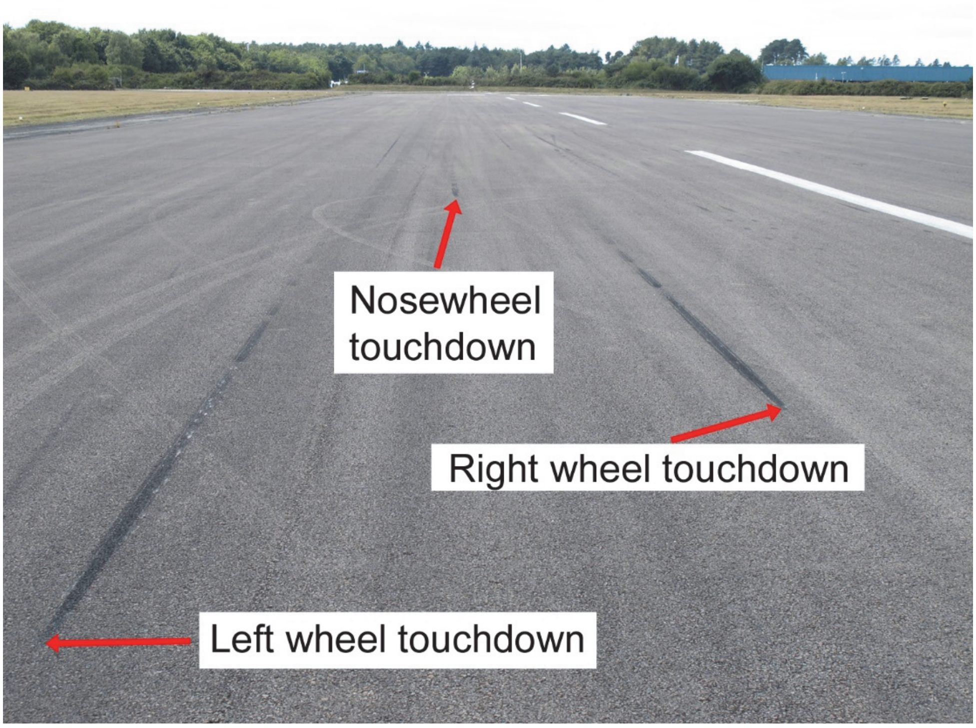

Figure 13

Touchdown tyre marks (looking in the direction of travel)

Figure 14

Tyre marks from touchdown to the end of the paved surface (white lines)
– GPS survey of marks overlaid on Google Earth image

Wreckage description

The aircraft departed the paved surface at the end of Runway 25 approximately 3 m to the left of the extended centreline. Ground impact marks indicated that it then collided with a one-metre high earth bank, causing the lower section of the nose landing gear and the nose gear doors to detach.

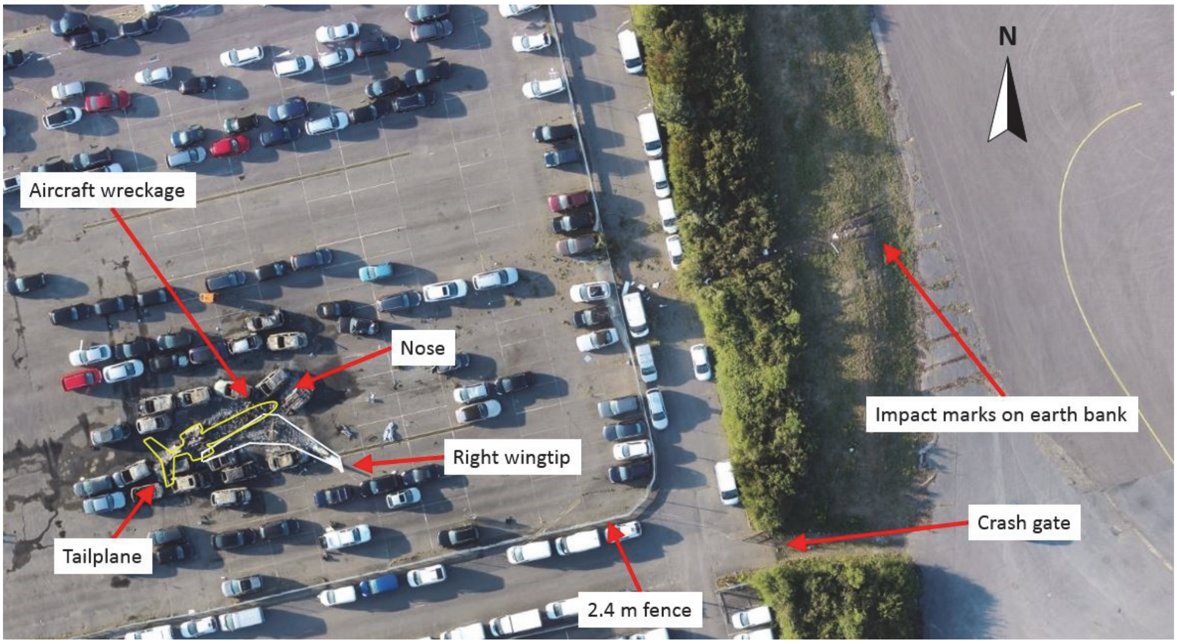

Figure 15

Overhead view of accident site, with outline showing wing and fuselage

An absence of ground contact marks between the earth bank and the fence surrounding the car park indicates that the aircraft then became airborne briefly, before colliding with several parked cars and then coming to rest approximately 70 m beyond the earth bank.

CCTV footage of the car park was reviewed by the AAIB. It showed the aircraft touched down in the car park in an approximately 20° right wing low roll attitude, and a level pitch attitude. Within 0.1 seconds of touchdown, the entire wing was observed to separate from the fuselage, following which the fuselage rolled to the left through approximately 350°, before coming to rest laying on its right side, on a heading of 064°M and at a roll angle of about 30° to the horizontal. The fuselage was observed to be largely intact as it came to rest, on top of the detached wing. The wing was oriented on a heading of north (Figure 15).

The first indications of fire visible on the CCTV footage occurred approximately 0.8 seconds after the aircraft's impact in the car park, as the fuselage was inverted following detachment of the wing (Figure 16). Visible flames were centred on the lower rear fuselage at the aft end of the fuselage belly fairing, immediately aft of where the wing was attached to the fuselage and close to the location of the aft main battery. The fire continued to burn with increasing intensity, consuming most of the aircraft.

Figure 16

CCTV image of aircraft approximately 0.8 seconds after touchdown in the car park (first visible indication of fire as the fuselage rolls through the inverted position)

The intensity of the post-accident fire, combined with disruption of the aircraft's structure due to impact damage meant that continuity of the aircraft's flying controls could not be established at the accident site. The six flap screwjack actuators were identified and their extensions measured; their positions corresponded to a flap deflection of 26°, flap lever position 2 or 3. Both spoiler PCU's were found in the retracted, spoilers closed, position.

The AAIB recorded the final location of the aircraft occupants. The pilot was located in the left cockpit crew seat; the right cockpit crew seat was unoccupied. The three passengers were located close to the cabin entry door, one close to seat one (Figure 9), a second close to seat two and the third adjacent to the cabin entry door.

Remains of the seat belt buckles from six of the seven passenger seats were recovered from the wreckage and all of those recovered were in an unfastened condition. One seat belt buckle was recovered from the cockpit; this was subsequently identified as the right cockpit crew seat buckle, and was in an unfastened condition. The pilot's seat harness buckle was not located in the aircraft wreckage and therefore its condition could not be determined.

Medical and pathological information

Post-mortem examinations were carried out by a Home Office pathologist. He found that all four occupants of the aircraft died from the effects of fire. Toxicological analysis found no alcohol or drugs in samples taken from the pilot's body.

The examinations found clear evidence of soot inhalation in larynx, trachea and small passages of the lungs, combined with blood carboxyhaemoglobin saturation[11] levels of between 40-60%[12], in all occupants. The post-mortem examinations did not identify any injuries not related to the fire that could have caused or contributed to death.

Rescue and firefighting service provision

The flight was private, and there was no regulatory requirement for it to use a licensed aerodrome or for rescue and firefighting cover to be available. However, the aerodrome was licensed, and Category 2 RFFS cover, which would have been suitable for a commercial transport flight by a similar aircraft, was available.

The aircraft came to rest approximately 70 m beyond the end of the runway's paved surface. CAP168, '*Licensing of Aerodromes*' sets out a requirement for emergency planning to cater for a response within 1,000 m of each runway threshold as follows:

Emergency planning/emergency orders

43. Emergency orders, which form part of the aerodrome manual, shall include arrangements for alerting the facility, for the immediate notification of other key aerodrome personnel and for summoning externally based emergency services. These orders shall detail procedures for anticipated emergencies including accidents/incidents which occur up to 1000 metres from the runway threshold. The areas within which a response will be made shall be shown in the aerodrome manual.

Footnote

11 Blood carboxyhaemoglobin is a compound formed in blood by the union of carbon monoxide and haemoglobin.

12 The pathologist commented that the level of carboxyhaemoglobin saturation, when death may be attributable to carbon monoxide toxicity alone, is greater than around 50%.

CAP 168 also sets out the requirement for an Aerodrome Manual and adds:

> *'The aerodrome manual is a key document both for the licence holder and the CAA'*

Under the heading 'Rescue and Fire Fighting Services it states that the manual should cover:

> *'Procedures indicating how accidents within 1000 m of the threshold of each runway are to be accessed.'*

In the section entitled *'Difficult environs, the 1000 m area and access roads'* the manual stated:

> *'Emergency access roads should be provided on an aerodrome where terrain conditions permit their construction, so as to facilitate achieving minimum response times. Particular attention should be given to the provision of ready access to approach areas up to 1000 m from the threshold, or at least within the aerodrome boundary. Where a fence is provided, the need for convenient access to outside areas should be taken into account.'*

And:

> *'With regard to access, licence holders should consider the following:*
>
> *…exit gates or frangible sections in the security fence'.*

The aerodrome operator had produced a training document for RFFS personnel entitled *'1000 meter overshoot'* which stated that *'RFFS at Blackbushe Airport have a responsibility to respond to any aircraft incidents within 1000 meters of the thresholds.'* The document described the Runway 07 threshold area as follows:

> ***'07 Threshold***
>
> *At the 07 threshold is a quarry owned by [name of quarry owner] which poses hazards to RFFS particular care should be taken by appliance drivers to where possible stick to the designated paths within the quarry.*
>
> *Also on the 07 threshold the Airports parent company BCA operates a large [commercial] site.*
>
> *Access to both these site are clearly marked and easily accessible the only exception is for out of hours flying where the quarry manager has given permission for Airport RFFS to cut the chain lock on the access gate.'*

The document included 13 photographs of the Runway 07 and 25 threshold areas, but none illustrated the gated access from the airfield into the commercial site and no mention was made of the gate or its padlock.

Chapter six of the aerodrome manual dealt with RFFS and medical services. It stated: *'To the western end is the car park of* [name of the commercial site owner] *site. Access is via an emergency gate adjacent to the runway end which permits access to the car park'* but no description of the means by which the gate was secured or could be opened was included. The aerodrome management commented that there had only ever been one set of keys for the crash gate between the aerodrome and the commercial site, kept in one vehicle.

Describing another area of land to the west of the aerodrome, the document stated: *'Further to the west is* [name of the landowner] *Land which is accessible via a series of locked gated tracks on either side of the A30'*. The document did not describe whether keys for these gates were available or where they were kept.

The aerodrome was subject to regular audits by the CAA. The most recent audit was carried out between 5 and 7 May 2015. The audit report included an observation, which had been carried over from the previous audit:

> *'During the audit the Inspector reviewed the emergency planning arrangements for the aerodrome, it was noted that details of the action to be taken in the case of aircraft accidents occurring outside the aerodrome boundaries were not well defined. Emergency Orders should contain details of the action to be taken in the case of aircraft accidents occurring outside the aerodrome boundaries.'*

On 22 June 2015, the aerodrome management responded to the CAA as follows:

> *'The actions to be taken are documented in the Aerodrome Manual in Appendix B, "Emergency Procedures", B.7. The ATSU will initiate the action by alerting the RFFS. Depending on the type of accident, the RFFS OiC will determine the level of response, i.e. one vehicle or two. If two vehicles are committed, then the ATSU will initiate a controlled closure of the Airport and broadcast the closure to all aircraft requiring the use of a licensed Airport.*
>
> *The RFFS Procedure Document, "Blackbushe Airport Fire & Rescue – 1000 Metre Overshoot" specifies the responsibilities of the RFFS within 1000 metres of the runway thresholds. This document is used as a training document in the on-going training programme for RFFS personnel, under Module 5 – Airfield Topography.*
>
> *In section B7 of Appendix B, "Emergency Procedures", there is a further procedure for dealing with domestic incidents in the close locality of the Airport.'*

Following this response, the CAA considered the observation to be closed.

The RFFS routine checks included a weekly check of the gates leading off the aerodrome and their locks, and these were last checked before the accident on 29 July 2015.

Survival aspects

Due to the resting attitude of the fuselage, in which the cabin entry door was on the upper left side of the fuselage, the aircraft manufacturer was requested to calculate the cabin door opening forces for this condition. Assuming no distortion of the cabin door frame or door latching mechanism, the manufacturer calculated that door opening loads were approximately 83 lbf when pressing on the lowermost integral door step, and 47 lbf when pressing on the centre integral door step. No force is required when the fuselage is in a level roll attitude because the door centre of gravity position results in a moment in the direction of door opening. The degree of distortion to the cabin door frame and door latching mechanism could not be determined following the accident due to fire damage of the door and its internal components.

Tests and research

Microlight altimetry

Ground calibration tests on the microlight's mechanical altimeter and altitude encoding transponder showed that both instruments were indicating accurately within required tolerances.

Pilot's viewpoint and visibility of the other aircraft

The design eye position, also known as eye datum or design eye reference point (DERP) is a key aspect of cockpit design. When positioned to achieve the design eye position, a pilot should be able to view all the main cockpit instruments while maintaining a reasonable external view outside the cockpit, with minimal head movement.

Figure 17 presents the perspective shape of the cockpit windows as observed from the left seat DERP. The following figures show the results of a perspective view analysis, taking account of the attitude of HZ-IBN and the positions of HZ-IBN, the microlight, and the light aircraft derived from radar. The angular size of the microlight and light aircraft is not represented in the figures; they are shown as points. Figure 18 provides the perspective view of the microlight as HZ-IBN approaches at 1406:54 hrs until just before it passes ahead at 1407:18 hrs; each position annotated is an average of 3 seconds apart with position 4 and 6 identifying when the TCAS TA and RA 'DESCEND' alert occurred. Figure 19 provides the perspective view of the light aircraft as HZ-IBN approached it between 1407:18 hrs and 1407:43 hrs; each position is 5 seconds apart with position 3 and 4 identifying when the RA 'ADJUST VERTICAL SPEED' occurred.

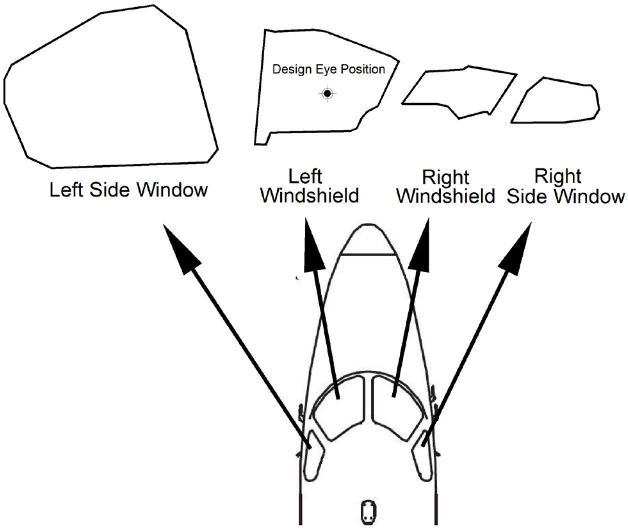

Figure 17

Perspective view of cockpit windows viewed from left seat design eye position

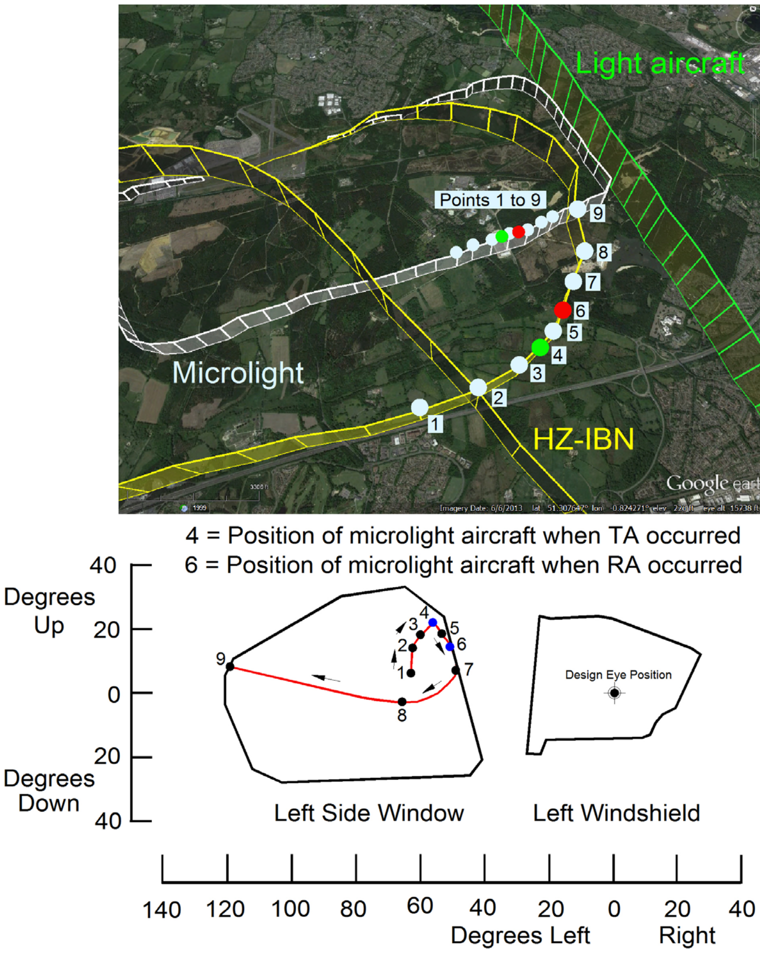

Figure 18

Perspective view of microlight viewed from HZ-IBN cockpit left seat design eye position 1406:54 hrs to 1407:23 hrs

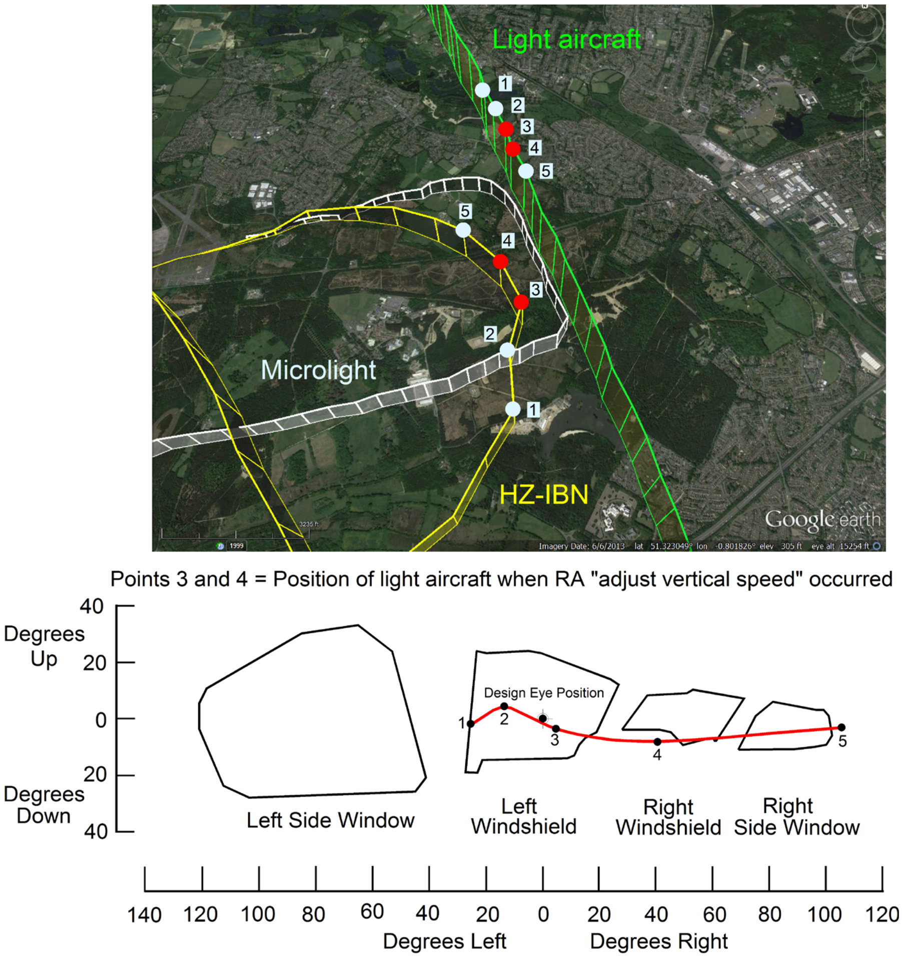

Figure 19

Perspective view of light aircraft viewed from HZ-IBN cockpit left seat design eye position 1407:18 hrs to 1407:43 hrs

Development of the fire

The UK Health and Safety Laboratory (HSL) was commissioned by the AAIB to produce a report detailing the development of the post-accident fire, and to determine the survivable time period within the aircraft's fuselage once the fire had ignited. In compiling its report, HSL reviewed CCTV footage and post-accident photographs of the car park accident site and the post-mortem reports of the deceased pilot and passengers. The HSL report contained the following findings:

- The near simultaneous impacts with a large number of vehicles brought the aircraft to a rapid halt and tore the wing from the fuselage.
- The detached wing came to rest almost directly beneath the fuselage. The leakage of fuel from the severed fuel lines occurred in an area adjacent to the fuselage.
- It is likely that petrol spilled from damaged vehicles hastened the fire spread in the early stages after the accident.

- Closely-spaced vehicles all around the wreckage reduced the rate of consumption of spilled fuel and hence increased the duration of the pool fire. In addition, burning of tyres and vehicle interiors added to the total rate of burning around the fuselage and increased the severity of the fire engulfment.
- The estimated survivable time period within the fuselage, following the aircraft's impact in the car park, was 1 minute 30 seconds. Two minutes and 30 seconds after this impact, slumping of the aircraft's tail section as captured on CCTV indicated widespread melting of the fuselage skin. Melting and yielding of the fuselage skin probably marked a relatively late stage in the complete destruction of the fuselage shell and linings, which would directly expose the interior of the cabin to the engulfing pool fire.
- The fully engulfing pool fire continued for more than four minutes after the slumping of the tail section of the aircraft. It is likely that the cabin was fully involved in the fire for most of this time.
- The pool fire was well established at the time the RFFS arrived at the crash gate that gave access to the car storage area. Within 15 seconds of their arrival at the gate, the fire had spread over the pool of spilled fuel and was rapidly taking hold in tyres and other exposed elements of vehicles.
- It took 1 minute and 12 seconds between the RFFS arriving at the crash gate and then continuing through it.
- The time taken to travel from the crash gate to the accident site, don protective safety equipment and deploy foam jets was 2 minutes 25 seconds.
- The closely-spaced burning vehicles around the crash scene would have made establishing effective foam coverage extremely difficult. Because the liquid spill was on a flat, unbounded surface, adding foam was unavoidably associated with extensions of the burning pool in some areas. The large number of vehicle fires also would have increased the difficulty of controlling the pool fire. Once the fire was established across the surface of the spilled fuel, it would have therefore been almost impossible to control the fire.
- The RFFS application of foam began about 5 minutes 10 seconds after the accident occurred. The overall fire size appeared to marginally increase for about 1 minute 45 seconds after the initial application of foam, and then started to drop rapidly. It seems likely that the pool fire burned out at this point.
- Had the RFFS began their attack one or two minutes earlier, then it is likely that the final duration of the fire would have been the same; the fire would have continued until the fuel was burned out.

Investigative techniques

An unmanned aircraft system (UAS) was used to obtain aerial images and video of the accident site. This aircraft weighs 1.24 kg and has a gyro-stabilised camera which can take 14 megapixel stills and 1080p resolution video. The aircraft was used in conjunction with image data capture software to fly the aircraft in a pre-programmed grid pattern while automatically taking a series of overlapping images with the camera pointing vertically downwards. These flights were conducted at a height of 30 m and 50 m. The images were then processed using photogrammetry software to generate a three-dimensional model and orthomosaic images of the accident site. Figure 15 is an example of one of the orthomosaic images.

Analysis

The accident flight

The accident flight was largely routine. The pilot was reportedly in good health and was familiar with the aircraft, destination and airspace, and with operating in a single-pilot role. The weather was good.

The operator had established systems beyond the requirements for private flying and had laid down standard operating procedures including stabilised approach criteria. The AFISO's statement that *'All of the approaches and departures that I have previously witnessed by this aircraft and by this pilot have seemed normal'* suggests that the pilot's previous performance did not cause him concern.

The aircraft was despatched with no deferred defects and no evidence of a technical defect was identified by the investigation.

The pilot

Neither post-mortem examination nor toxicological testing identified anything that would have reduced the pilot of HZ-IBN's operating performance.

Preparation for the arrival

Because the aircraft was being flown as a single-pilot operation, there was no need for a verbalised briefing for the arrival, and it was not possible to determine to what extent the pilot had briefed himself either before or during the flight. The briefing material available to him did include the IAIP advice and instructions concerning missed approaches. A comprehensive briefing for the arrival could have taken account of several identifiable threats or hazards, and use of the operator's risk assessment tool could have assisted the pilot in identifying some or all of the threats. It was not possible to establish whether a formal risk assessment had been carried out. In particular, it was not possible to determine whether the pilot of HZ-IBN had considered what go-around options and profiles were available to him should it be necessary to discontinue the approach. Deciding to go around is more straightforward if the necessary speeds, configurations, and vertical and lateral path to be followed, have been mentally rehearsed beforehand.

Co-ordination of the aircraft's arrival to Blackbushe AFISOs

The inbound estimate passed by Farnborough ATC to the AFISO at Blackbushe (an estimate for Goodwood in the case of HZ-IBN), gave notice of the aircraft's arrival to the AFISO but did not specify precisely the moment at which it would need to integrate into the traffic pattern. The recommended procedure, by which a 'ten mile check' should have been passed by Farnborough to Blackbushe, was more likely to assist the AFISO. The AFISO's response to HZ-IBN on first contact (enquiring whether the aircraft was coming in from the south), indicated that the AFISO's situational awareness was not optimal.

AFISOs are not permitted to issue instructions to aircraft in the air, but they may suggest a course of action to facilitate traffic joining the circuit, and if the ten mile check had been passed, a suggestion could have been made that HZ-IBN join on base leg. Some pilots familiar with Blackbushe and AFISOs agreed that this was preferable, as a means of integrating faster and slower aircraft, than them performing a standard join and then resolving speed differences within the traffic pattern. When HZ-IBN approached the aerodrome, the microlight in the circuit was only recently airborne, and a base leg join could have been made without conflict.

At Blackbushe, the constricted nature of the airspace meant that the downwind leg of the circuit must be flown close to the aerodrome. HZ-IBN flew downwind 1.6 nm from the runway, consistent with the 1.5 nm stipulated by the operator, and at 2,000 ft.

The flight proceeded without incident until the visual circuit. The pilot's contact with Blackbushe Information at 1346 hrs indicates that he was thinking ahead of the aircraft. Whilst under control of Farnborough Radar, he was initially given radar vectors towards a downwind position, with the expectation of a visual approach, which logically would have been from the east towards Blackbushe. However, the controller then changed his plan and directed HZ-IBN overhead the aerodrome. The Farnborough controller was not aware of the disposition of traffic in the circuit at Blackbushe and this direction towards the overhead was a default instruction, not the result of consideration of the circumstances. Although the pilot of HZ-IBN would have needed to amend his mental model to ensure that his situational awareness took account of the amended route, this was a straightforward change and subsequent events show that he did have a plan for the arrival in the Blackbushe circuit.

When HZ-IBN was instructed to contact Blackbushe Information, the pilot selected VHF 2 to transmit, rather than selecting the Blackbushe frequency on VHF 1; he also left VHF 1 audible and at a greater volume than VHF 2. The subsequent transmissions on the Farnborough frequency may have added to his situational awareness, but also had potential to cause distraction, masking other sources and decreasing the pilot's mental capacity. This would have had a negative impact on his situational awareness.

Progress of the flight into the circuit

Although there was a lack of clarity in some of the pilot's communications, there was consistency in the intentions which he expressed. His initial call, "coming on overhead the airport and i will be turning downwind soon for runway two five maintaining two thousand feet" indicates that his plan was to join the circuit and continue around it, but at 2,000 ft amsl, which would have enabled him to give way to the microlight by letting it fly a normal circuit and land first. Although the airspace around Blackbushe is congested, the airspace east of the aerodrome is sufficient for an extended downwind leg to be flown for several miles.

The pilot's enquiry about the altitude of the circuit traffic indicates that he was taking account of it in developing his plan. Extending the downwind leg of his circuit to allow the microlight to land would prevent a conflict and satisfy the relevant rules.

By joining the circuit overhead the runway, the pilot maximised the time available to configure the aircraft, reduce speed and height, and manoeuvre towards the final approach, within the airspace constraints. He and the microlight instructor had acknowledged each other's presence, and the pilot of HZ-IBN had reported visual contact with the microlight to the AFISO, before the first TA was generated.

Responsibility for avoiding conflict lay with the pilot of HZ-IBN, because HZ-IBN would overtake the microlight.

The AFISO's response to the microlight instructor's downwind call, "[microlight's abbreviated callsign] roger i'm not sure how this is going to work [microlight instructor's forename]" indicated his concern that a conflict might develop. The microlight instructor then proposed a resolution: "er [afiso's first name] we'll extend on downwind to let the jet in [brief pause] jet in first if you're happy with that". The AFISO acknowledged this: "that might work break break hotel bravo november did you copy that". The pilot of HZ-IBN responded, "i copy that i was doing the same for him but in this is the case i'll just er descend and do my landing".

This response from the pilot of HZ-IBN was the first statement of his plan, but was revealed after the contrary plan had been proposed and agreed.

If an air traffic control service had been in place at Blackbushe, a suitably-qualified controller could have issued appropriate instructions to resolve the potential conflict, instead of relying on the suggestion of one of the pilots involved.

The pilot of HZ-IBN disconnected the autopilot and began a descent, which he reversed into a slight climb as his aircraft approached the microlight. As the climb began, the TCAS issued a "descend" RA, and the microlight began a slight climb towards, and underneath, HZ-IBN. The pilot of HZ-IBN then pitched his aircraft up more aggressively and applied significant thrust. As these events unfolded, his workload rose, and he would have needed to make rapid changes to his mental model.

Examination of the Phenom 300 design eye position and radar data indicated that the microlight and overflying light aircraft would have been in the Phenom pilot's field of view at the time of relevant TCAS alerts. It is possible that he climbed the aircraft instead of following the TCAS "DESCEND" RA because he was manoeuvring visually to avoid the microlight.

The TCAS aural annunciation "TRAFFIC, TRAFFIC" had occurred at the same time as a transmission on the Farnborough frequency, and may have been masked by it, making the presentation of the RA unexpected and startling the pilot. This is often associated with a follow-on reflex action: in this case, an intuitive further pitch-up input and aggressive application of thrust[13]. Further confusion could have been generated by the contradiction between the recently-begun climb, the presence of the microlight below HZ-IBN, and the descend RA. Such contradictory circumstances give rise to cognitive dissonance[14], which can contribute to mental stress.

The pilot was exposed to 36 aural inputs during a period of 2 minutes and 19 seconds, in the dynamic circumstances leading to the end of the downwind leg. He disconnected the autopilot and took manual control, first descending then climbing to avoid the developing conflict with the microlight.

As the curving base leg continued, the climb was reversed into a steep descent significantly above the appropriate approach speed, and thrust was reduced to idle. The pilot's selection of speed brake had no effect because they do not deploy when flap has been extended.

The TCAS RA generated by the conflict with the microlight continued, then changed to provide resolutions relative to the overflying aircraft as well. The various aural annunciations gave way to a series of TAWS warnings, interspersed with other automatic announcements and the AFISO's instruction to land at the pilot's discretion, which might ordinarily be associated with normal progress. To these were added the loud transmissions on the Farnborough frequency. This would have produced a challenging aural environment, involving a further 30 aural inputs in the 1 minute 13 seconds before the aircraft overflew the threshold.

Multiple aural inputs and the need to make avoidance manoeuvers created a high-workload situation, in the course of what was already a more than usually demanding approach.

It is possible that in these circumstances the pilot of HZ-IBN fixated on his initial strategy (landing) and lacked the mental capacity to recognise that the approach had become unstable and should be discontinued. The approach continued towards the normal touchdown area, giving no immediate visual cue of an unacceptable touchdown position. The absence of a response to the AFISO's transmission informing the pilot that he could land is consistent with the pilot's workload having reached a point at which he could no longer process his aural environment or perceive critical information.

Although the approach trajectory was towards the normal touchdown area, the speed was very high: the correct target speed was 108 KIAS and the aircraft crossed the threshold at 151 KIAS. It is possible that the pilot of HZ-IBN was aware of the high speed, but believed

Footnote

13 The appropriate response to a "DESCEND" RA would not be to enter a climb.
14 A state of psychological tension arising from incompatible attitudes, behaviour, beliefs, and/or knowledge.

that the landing could be achieved. Alternatively he may not have appreciated how fast the aircraft was flying, perhaps because he was fixated on landing.

As the aircraft approached the runway the pilot made a progressive nose-up pitch input, the pitch attitude increasing from approximately 8° nose-down towards a level attitude in the last 200 feet of the approach. This arrested the rate of descent and the aircraft 'floated' along the runway before touching down with only 438 m of runway surface remaining. At the high speed at which the landing was attempted, the aircraft would have responded more sensitively to pitch inputs than during a normal landing, making an accurate touchdown difficult.

The AFISO's action, in activating the crash alarm before the accident had happened, assisted in the emergency response. However, a fire broke out before the aircraft had come to rest, and developed rapidly.

CAP168 gave instructions concerning the provision of rescue and firefighting services in the 1,000 m area, which emphasised the importance of access and mentioned access, fences, and gates. However, the aerodrome's manual and training material did not identify the locked gate between the aerodrome and the car park, and made no mention of keys. The CAA audit had reiterated the previous audit observation that:

> *'details of the action to be taken in the case of aircraft accidents occurring outside the aerodrome boundaries were not well defined. Emergency Orders should contain details of the action to be taken in the case of aircraft accidents occurring outside the aerodrome boundaries'*

and a thorough examination of these orders could have identified the need for keys to be carried on each RFFS vehicle.

Engineering

A review of the aircraft's maintenance records did not identify any discrepancies and there was no evidence to suggest that the aircraft was not airworthy prior to the accident occurring.

Touchdown and deceleration

The tyre marks revealed that the left wheel touched down first, followed by the right wheel about 0.06 seconds later. This is also evidence in the CVFDR data which shows the left wheel speed rising faster than the right wheel speed. The WOW sensors did not transition to 'ground' until about 1.3 seconds after the left wheel speed increased, which indicated that it was a light touchdown. Brake pressure can be applied before the WOW sensors transition to 'on ground' if both wheel speeds are above 60 kt. This explains why the left brake pressure increased only 0.5 seconds after left wheel touchdown. This indicated that the pilot applied the brake pedals before or within 0.5 seconds of touchdown.

The right brake pressure rose more rapidly than the left brake pressure, which is consistent with the more continuous tyre marks from the right wheel. This was probably due to a normal difference in anti-skid system operation between the left and right wheel brakes. Both wheel speeds reduced at a similar rate 1.2 seconds after touchdown, consistent with the reduction in groundspeed. The difference of about 10-15% between the recorded wheel speed and recorded groundspeed is due to braking. This is consistent with the optimum slip ratio[15] for maximising braking friction on a dry surface.

The average deceleration of -0.45g, achieved 2.7 seconds after touchdown, indicated that the brakes were operating effectively and at a marginally higher level than that assumed in the unfactored performance charts.

A lack of runway friction did not contribute to this accident: at the point and speed at which the aircraft touched down, there was an insufficient runway remaining in which to stop the aircraft.

The spoilers deployed fully within 1.2 seconds of the wheel speeds starting to increase, as designed. The last CVDR data point shows the spoilers starting to retract, probably because the thrust levers were being moved forward of the IDLE position, and explains why the spoiler actuators were found retracted at the accident site.

Fire analysis

The CCTV images showed that the fire ignited approximately 0.8 seconds after the detachment of the aircraft's wing assembly, with the initial seat of the fire located in the aft belly fairing, just behind where the wing had detached. The only significant fuel source in this area was fuel leaking from the severed wing-to-fuselage engine fuel supply fuel pipes, which contained fuel fed from the wing fuel tanks. The ignition source of the fire was not positively identified due to disruption of the aircraft in the accident and from the severity of the post-accident fire.

Once the fuselage came to rest on top of the detached wing, the fire continued to burn, which then ignited fuel leaking from the wing main fuel tanks. This significantly increased the severity of the fire approximately 46 seconds after the initial impact in the car park. The RFFS vehicles began application of foam to the fire 5 minutes 10 seconds after the aircraft's impact in the car park, however this marginally increased the overall fire size over the next 1 minute 45 seconds, until the fire size started to drop rapidly. It is likely that the pool fire had consumed the available fuel at this point.

Survivability

The results of the post-mortem examinations of the pilot and passengers showed that all four occupants of the aircraft survived the impacts in the car park and that they subsequently succumbed to the effects of the post-accident fire.

The location of the deceased passengers in the aircraft wreckage, adjacent to the cabin entry door, suggests that they may have attempted to vacate the aircraft via the cabin entry

Footnote

15 The slip ratio is the ratio of wheelspeed to groundspeed minus 1. Friction is a function of the slip ratio and the anti-skid system targets to operate at the friction peak.

door, but that their attempt proved unsuccessful. Analysis by the manufacturer for the case of no distortion to the cabin door aperture or its latching mechanism showed that the door opening loads, for the fuselage resting at an angle of 30° to the right in roll, were not excessive. The effects of the post-accident fire made it impossible to assess the degree of distortion to either cabin door itself, its aperture in the fuselage structure or any distortion to the door latching mechanism; any one of these may have increased the door opening loads to the point that it could not be opened by the occupants. The rapid increase in the severity of the fire 46 seconds after impact in the car park may have adversely affected the occupants' ability to attempt to open the door.

It was estimated that the survivable time period within the aircraft's fuselage, following its impact in the car park, was 1 minute 30 seconds. CCTV images showed that at 2 minutes 30 seconds after the impact in the car park there was widespread yielding and melting of the fuselage skin, which would directly expose the interior of the cabin to the engulfing pool fire.

The pool fire was well established at the time the RFFS arrived at the crash gate that gave access to the car storage area, 1 minute 35 seconds after the accident occurred. The time taken to travel from the crash gate to the accident site, don protective safety equipment and deploy foam jets was 2 minutes 25 seconds. Despite the delay of 1 minute 12 seconds between the RFFS arrival at the crash gate and their continuing through it, it is likely that the final duration of the fire would have been the same had the delay not occurred – the fire would have continued until the fuel was burned out and was not survivable.

Conclusion

The pilot was appropriately licensed and experienced, and had operated into Blackbushe Aerodrome on 15 previous occasions. He was reported to be physically and mentally well. The aircraft was certified for single-pilot operations and the pilot was qualified to conduct them.

The engineering investigation of the accident aircraft did not find evidence of any pre-existing technical defect that caused or contributed to the accident. The meteorological conditions were suitable for the approach and landing and, at the actual landing weight and appropriate speed, a successful landing at Blackbushe was possible.

HZ-IBN joined the circuit at a speed and height which would have been consistent with the pilot's stated plan to extend downwind in order that the microlight could land first. The subsequent positioning of HZ-IBN and the microlight involved HZ-IBN manoeuvring across the microlight's path, in the course of which the first of several TCAS warnings was generated.

After manoeuvring to cross the microlight's path, HZ-IBN arrived on the final approach significantly above the normal profile but appropriately configured for landing. In the ensuing steep descent, the pilot selected the speedbrakes out but they remained stowed because they are inhibited when the flaps are deployed. The aircraft's speed increased and it crossed the threshold at the appropriate height, but 43 KIAS above the applicable target threshold speed. The excessive speed contributed to a touchdown 710 m beyond the threshold, with only 438 m of paved surface remaining. From touchdown, at 134 KIAS, it was no longer possible for the aircraft to stop within the remaining runway length.

The brakes were applied almost immediately after touchdown and the aircraft's subsequent deceleration slightly exceeded the value used in the aircraft manufacturer's landing performance model. The aircraft departed the paved surface at the end of Runway 25 at a groundspeed of 83 kt.

The aircraft collided with an earth bank and cars in a car park beyond it, causing the wing to separate and a fire to start. Although the aircraft occupants survived these impacts, they died from the effects of fire.

Towards the end of the flight, a number of factors came together to create a very high workload situation for the pilot, to the extent that his mental capacity could have become saturated. His ability to take on new and critical information, and adapt his situational awareness, would have been impeded. In conjunction with audio overload and the mental stressors this can invoke, this may have lead him to become fixated on continuing the approach towards a short runway.

Safety actions

Operator

The operator of HZ-IBN reported that the company has instituted the following changes since the accident:

1. Since July 31, 2015, all Phenom 300 flights are operated with both a commander and co-pilot. The operator may develop a risk analysis process which will assess the risk of each flight in order to determine if a single-pilot operation can be justified only to allow operational flexibility, for example, on short flights in relatively low-workload environments.

2. The operator is adopting a Flight Operations Quality Assurance (FOQA) program. Appropriate hardware had been identified and ordered by January 2016 and delivery was awaited. The programme was due to be in operation by the end of March 2016.

3. The Stabilized Approach for VMC approach and landings has been amended to 500 ft agl.

4. All pilots have successfully completed Upset Prevention and Recovery Training (UPRT) in order to add an additional layer of safety and combat LOC-I[16].

Footnote

[16] Loss of Control in Flight.

5. Enhanced Recurrent Training Requirements have been introduced, with training providers be requested to focus on short runway operations and incorporate scenarios which require pilots under training to make time critical decisions with respect to landing performance and runway distances required.

6. The standardised approach brief now focuses on go-arounds in VMC, to ensure that flight crew are prepared to go around, and set safe margins for landing performance.

7. Mandatory pilot and team meetings have been introduced. Previously, scheduling challenges had made it difficult to get pilots and other staff together for regular meetings to discuss operational challenges, and so reliance was placed on a system of independent briefings. In order to achieve better exchange of safety and operational information, pilots, dispatch staff, maintenance staff, and others, will be rostered for regular meetings.

Farnborough Air Navigation Service Provider (ANSP)

The ANSP at Farnborough carried out an investigation following the accident and made the following recommendations:

Recommendation 1: It is recommended that a full review is carried of the Farnborough letter of Agreements with local airfields to ensure operational aspects are not onerous on the Farnborough operation and the MATS2[17]/LOA[18] procedures align.

Recommendation 2: It is recommended that a safety survey or review is carried out into the provision of ATSOCAS[19] at Farnborough. This survey/review should focus on whether controllers are providing an appropriate service with appropriate service reductions when controllers' workload is high or while traffic is operating within areas of high traffic density.

Recommendation 3: It is recommended the unit GM[20] assesses whether there is a need to explore a method of utilising the intention codes of CCAMS[21] squawks to make them more easily identifiable on the CWP[22] and when using the unit codes function it also displays CCAM squawks operating into a Farnborough Clutch airfield.

Footnote

17 Manual of Air Traffic Services Part 2.
18 Letter of Agreement.
19 Air Traffic Services Outside Controlled Airspace.
20 General Manager.
21 Centralised SSR Code Assignment and Management System.
22 Controller Work Position.

Aerodrome

> The aerodrome operator reported that crash gate keys are now carried aboard each RFFS vehicle, and that it has amended its operational and training documentation to reflect the presence of locked gates and the means of opening them.

BULLETIN CORRECTION

The above Field Investigation Report contained an error in the 'Survival aspects' section (page 34). The original text stated '*right side of the fuselage'* but should have stated '*left*'. The first sentence of this section should now read:

> Due to the resting attitude of the fuselage, in which the cabin entry door was on the upper **left** side of the fuselage, the aircraft manufacturer was requested to calculate the cabin door opening forces for this condition.

The online version of the report was amended on 12 January 2017.