AAIB
Air Accidents Investigation Branch

AAIB Bulletin 2/2015

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Air Accidents Investigation Branch
Farnborough House
Berkshire Copse Road
Aldershot
Hants GU11 2HH

Tel: 01252 510300
Fax: 01252 376999
Press enquiries: 0207 944 3118/4292
http://www.aaib.gov.uk

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MISCELLANEOUS

ADDENDA and CORRECTIONS

(ALL TIMES IN THIS BULLETIN ARE UTC)

AAIB Field Investigation reports

A field investigation is an independent investigation in which AAIB investigators collect, record and analyse evidence.

The process may include, attending the scene of the accident or serious incident; interviewing witnesses; reviewing documents, procedures and practices; examining aircraft wreckage or components; and analysing recorded data.

The investigation, which can take a number of months to complete, will conclude with a published report.

SERIOUS INCIDENT

Aircraft Type and Registration:	Gulfstream 550, HZ-A6	
No & Type of Engines:	2 Rolls-Royce BR710C4-11 turbofan engines	
Year of Manufacture:	2004	
Date & Time (UTC):	10 December 2013 at 0325 hrs	
Location:	Stansted Airport, Essex	
Type of Flight:	Commercial Air Transport	
Persons on Board:	Crew - 4	Passengers - 3
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Underside of left wing and left landing gear door	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	53	
Commander's Flying Experience:	8,685 hours (of which 1,311 were on type) Last 90 days - 70 hours Last 28 days - 0 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft was carrying out a charter flight from Riyadh in Saudi Arabia to London Stansted Airport. It was radar vectored for a CAT I, ILS DME approach to Runway 22 at Stansted with the autopilot (AP) and autothrust (AT) engaged. Conditions at the time were below the CAT I approach minima. With the aircraft fully established on the approach, the AP and AT were disengaged at 1,600 ft aal and the aircraft was hand flown by the commander for the remainder of the approach and landing. The localiser was maintained, but the aircraft flew above the glidepath before descending through it. For reasons that could not be established, go-around mode was selected, which would have inhibited the EGPWS glideslope warnings. In the final stages of the approach the aircraft was well below the glideslope, causing it to strike the Runway 22 ILS localiser monitor aerial and the Runway 04 localiser aerial array, before touching down short of the Runway 22 threshold.

The accident occurred as a result of the pilot continuing to land from a destabilised approach, rather than performing a go-around.

History of the flight

The flight crew reported for duty at 1730 hrs and carried out the normal flight planning, which included reviewing the weather. The TAF for Stansted covering the aircraft's ETA gave a 40% probability of fog between 0300 hrs and 1000 hrs, with a surface visibility of 500 m and cloud overcast at 100 ft. The weather at Manchester Airport, the selected alternate, was forecast to be 10 km visibility with cloud FEW at 3,500 ft for the same period.

The commander was the pilot flying (PF) and the co-pilot was the pilot monitoring (PM). There was one deferred defect, concerning the commander's audio control panel which had the mask/boom selector button stuck in the mask position, but with the hand-held microphone available to the commander, this defect was accepted.

The aircraft departed at 2001 hrs and, following an uneventful flight, commenced a descent for a CAT I[1] approach into Stansted. The Stansted ATIS was recorded as:

> Information Bravo, Runway 22 at time 0220 hrs, wind 160º at 04 kt, Runway 22, Runway Visual Range (RVR) 250 m in fog with broken cloud at 100 ft, temperature 2ºC with a dew point 1ºC and a QNH of 1030 hPa.

This was updated at 0250 hrs with Information Charlie, which was essentially the same but with the RVR increased to 300 m and the temperature and dew point both 1ºC. The crew reported that they carried out the normal and missed approach briefings for the ILS DME approach for Runway 22 at Stansted Airport, with the alternate as Manchester Airport.

The aircraft was radar vectored for the ILS to Runway 22 and cleared by ATC for the approach. The landing weight was 63,000 lbs, with a V_{REF} of 126 kt IAS to which 5 kt had to be added, giving a V_{APP} of 131 kt. The localiser and glideslope upper modes of the autopilot were armed and the autothrust was engaged. The localiser was intercepted at 10.84 nm and the glideslope at 8.41 nm from the runway threshold.

The aircraft successfully captured the localiser and descended with the glideslope. The crew changed to the Tower radio frequency, established radio contact at 6 nm, and were issued with the following landing clearance: "HZA6 THE SURFACE WIND 170 5 KNOTS YOU'RE CLEARED TO LAND RVR 325, 400 300". This was acknowledged by the co-pilot transmitting: "CLEARED TO LAND HZA6". At 5 nm and a height of 1,625 ft, the flaps were commanded to fully down. The speed was 181 kt IAS, which is above the flap limiting speed of 170 kt IAS and an overspeed audio warning was generated. The flap travel was stopped at 20º and, shortly thereafter, the autopilot was disengaged. The flaps were reselected to the fully down (landing) position at 4.3 nm.

At 4 nm the autopilot was re-engaged but shortly thereafter, at a height of 1,212 ft, the autopilot was disengaged and at 3.6 nm and a height of 1,388 ft and 165 kt, the autothrust was disengaged. The aircraft was significantly above the glideslope at this point, prompting ATC to advise the crew: "HZA6 INDICATING SLIGHTLY HIGH ON THE GLIDEPATH CONFIRM CORRECTING", to which the co-pilot responded: "YES WE ARE CORRECTING". At 3 nm, the autopilot was again engaged, but almost immediately disengaged and the commander hand flew the aircraft in a descent towards the glideslope.

The pilots reported that, throughout the approach, they both had the approach and runway lights in sight, but did not see the PAPIs. At 1.7 nm, for reasons that could not be established, the autopilot mode, autothrust and vertical mode all changed to

Footnote

[1] For a CAT I approach the RVR must not be less than 550 m.

go-around[2], but the commander continued to fly the aircraft towards the runway. Continuing the approach from that point was carried out by visual reference to the approach and runway lighting.

At 1.0 nm the aircraft was at a height of 237 ft, 120 ft below the glideslope and it continued to descend to 30 ft at 0.3 nm, 130 ft below the glideslope. At a height of 11 ft and just under 0.2 nm from the runway threshold, the lower part of the fuselage and landing gear struck the Runway 22 ILS localiser monitor aerial and the Runway 04 localiser aerial array. The aircraft continued in the flare at a height of 3 ft at 0.1 nm from the threshold, before touching down at 108 kt on the concrete surface of the runway undershoot area, 55 ft below the glideslope and 109 ft short of the runway threshold.

During the final approach there were no EGPWS warnings, apart from the normal radio altimeter height 'callouts' and 'APPROACHING MINIMUMS' alert, which were heard on the CVR. The passengers and crew were unaware of the impact with the aerials and it was not until the aircraft was taxied to the parking area and the after flight inspection was carried out that the damage was seen.

Regulatory requirements

The aerodrome operating minima requirements for foreign aircraft being operated in the United Kingdom are set out in Article 108 of the United Kingdom Air Navigation Order (UK ANO) 2010 as follows:

'Article 108 - Public transport aircraft registered elsewhere than in the United Kingdom-aerodrome operating minima

(1) This article applies to public transport aircraft registered elsewhere than in the United Kingdom.

(2) An aircraft to which this article applies must not fly in or over the United Kingdom unless the operator has made available to the flight crew aerodrome operating minima which comply with paragraph (3) for every aerodrome at which it is intended to land or take off and every alternate aerodrome.

(3) The aerodrome operating minima provided in accordance with paragraph (2) must be no less restrictive than either:

(a) minima calculated in accordance with the notified method for calculating aerodrome operating minima; or

(b) minima which comply with the law of the country in which the aircraft is registered,

Whichever are the more restrictive.

Footnote

2 Selecting the go-around mode changes the Primary Flight Display (PFD) from an ILS presentation to the horizontal and vertical go-around presentation. ILS guidance is no longer provided and the EGPWS Mode 5 'GLIDESLOPE' warning is no longer available.

An aircraft must not:

conduct a Category II, Category IIIA or Category IIIB approach and landing; or
take off when the relevant runway visual range is less than 150 metres,

otherwise than under and in accordance with the terms of an approval to do so granted in accordance with the law of the country in which it is registered.

An aircraft must not take off from or land at an aerodrome in the United Kingdom in contravention of the specified aerodrome operating minima.

Without prejudice to paragraphs (4) and (5), when making a descent to an aerodrome an aircraft must not descend from a height of 1000 feet or more above the aerodrome to a height of less than 1000 feet above the aerodrome if the relevant runway visual range at the aerodrome is at the time less than the specified minimum for landing.

Without prejudice to paragraph (4) and (5), when making a descent to an aerodrome an aircraft must not:

continue an approach to landing at an aerodrome by flying below the relevant specified decision height; or descend below the relevant specified minimum descent height, unless, in either case, the specified visual reference for landing is established and maintained from such height.

(8) In this article 'specified' means specified by the operator in the aerodrome operating minima made available to the flight crew under paragraph (2).'

Aerodrome information

London Stansted Airport (EGSS) has a single runway orientated 04/22, 3,049 m long and 46 m wide. The runway in use at the time of the accident was Runway 22, which has a threshold elevation of 348 ft. It is equipped with approach lighting, runway, threshold and stop end lighting, and PAPIs set to an angle of 3.0º.

The runway is equipped with an ILS capable of CAT I, II and III operations for suitably equipped and authorised aircraft. The ILS is frequency paired with the DME on 110.5 MHz. The runway and approach lighting and radio navigation aids were fully serviceable throughout the approach. The Final Approach Track was 224º with a magnetic variation of 1.3º W.

The crew were carrying out a CAT I, QNH approach for which the minima are: Decision Altitude 548 ft and a minimum Runway Visual Range (RVR) of 550 m.

A copy of the Jeppesen approach chart used by the crew is shown at Figure 1.

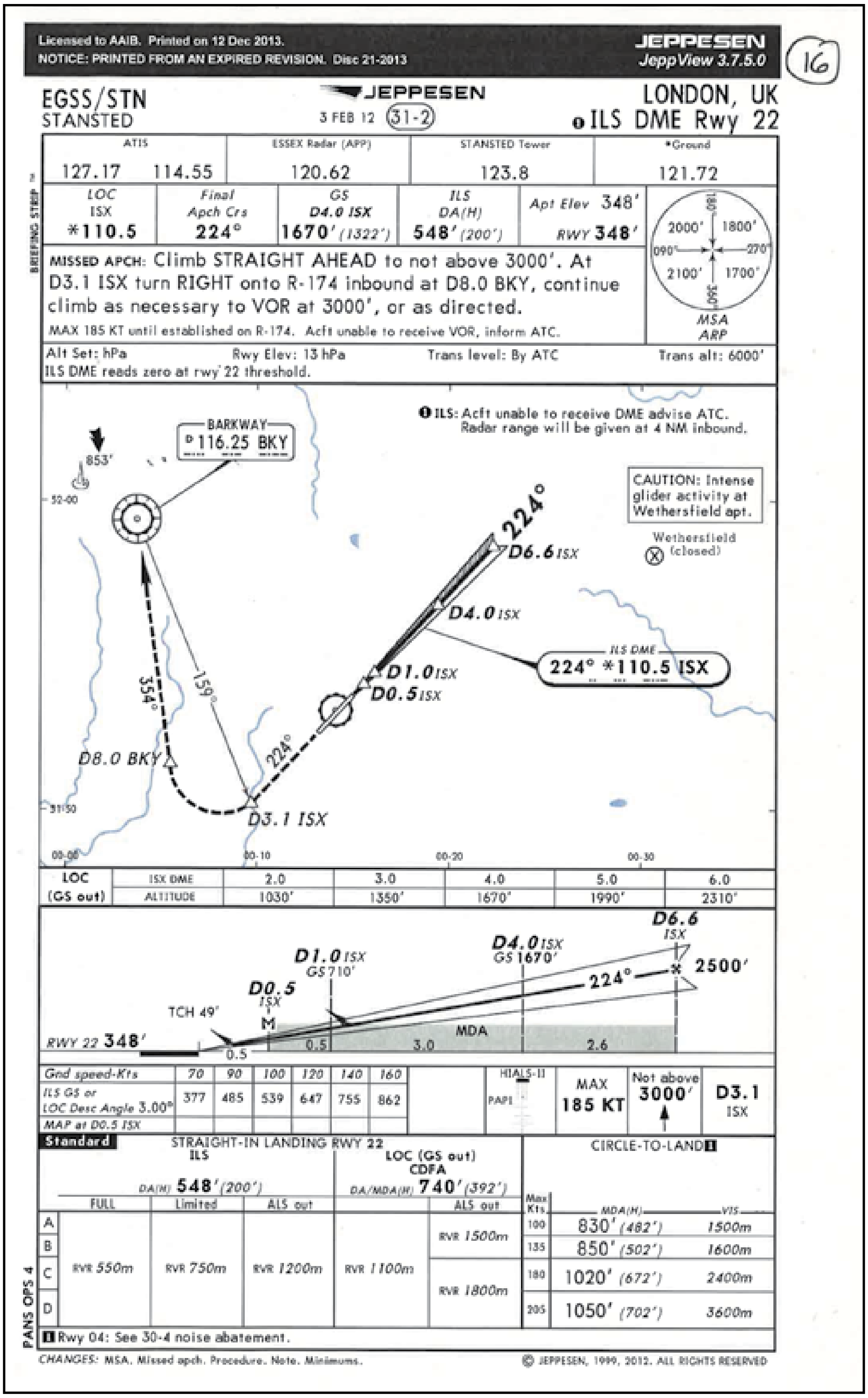

Figure 1

London Stansted Runway 22 ILS DME approach chart

Meteorology

The general situation for the night of the accident was a high pressure system centred over Europe which created light southerly winds and relatively high humidity over the United Kingdom. This created a risk for deterioration in visibilities and low cloud which eventually occurred. At Stansted the visibility dropped quickly through the evening to less than 1,000 m before 2200 hrs, then going into fog for the remainder of the night.

The Stansted (EGSS) and Manchester (EGCC) Terminal Aerodrome Forecasts (TAF) provided to the crew in their briefing pack were as follows:

EGSS 0912/1018 24010KT 9999 FEW014 SCT025 PROB30 0912/0913 4000 BR BKN004 BECMG 0916/0919 18006KT 6000 TEMPO 0919/1010 3000 BR PROB40 1003/1010 0500 FG OVC001 BECMG 1010/1012 9999

EGCC 0912/1018 20007KT 9999 FEW035

The Stansted METARs covering the landing time of 0325 hrs were:

100320Z EGSS 100320Z 18005KT 0400 R22/0325 MIFG SCT001 01/00 Q1030
100350Z EGSS 100350Z 16005KT 0400 R22/0275 FG OVC001 01/00 Q1030

The commander of an aircraft which landed at 0319 hrs, six minutes ahead of HZ-A6, provided the following description of the conditions during his approach, which was conducted as a CAT III Autoland:

> *'We were flying a Boeing 737-300 engaged on a CAT 3a approach onto RWY 22 at STN, the TDZ RVR was being given as 350 m in Fog. Our approach was uneventful and the required visual reference was easily achieved by our decision height of 50 ft Radio followed by a normal autoland and exit from the runway. All ILS transmissions, runway and approach lighting were functioning normally.'*

As the pilot was concentrating on elements of the approach/runway lights, he was not aware of the PAPIs. He also stated that:

> *'The flying conditions were very clear above about 100 ft and runway and approach lights were clearly individually visible apart from a section of runway about 200 metres long approximately one third of the length of the runway from the 22 runway end that obscured the lighting from individual lights to merely a glow. Although the fog bank was entered at around 100 ft determination of approach and runway lighting was not difficult.'*

The crew of HZ-A6 also reported that they could clearly see the approach and runway lighting throughout the approach.

Company General Operations Manual

The operator had set out in the company General Operations Manual (GOM) the requirements for conducting Terminal Instrument Procedures. Of relevance to the accident, the Company Policy and Procedures set out at paragraph 18.40.8 stated:

> *'Approaches to airports where the weather is reported below published landing minimums are not authorized'*

The Article 108 requirement stipulated in the UK ANO and set out below was not included here or in any other part of the operator's GOM:

> *'Without prejudice to paragraphs (4) and (5), when making a descent to an aerodrome an aircraft must not descend from a height of 1000 feet or more above the aerodrome to a height of less than 1000 feet above the aerodrome if the relevant runway visual range at the aerodrome is at the time less than the specified minimum for landing.'*

The operator had also set out the maximum deviation parameters during the approach phase in order to ensure a stabilized approach. These were:

> *'1.1.3 Approach Phase*
>
> *The maximum deviation parameters are:*
>
> - *One dot deviation from glide slope.*
> - *½ dot deviation from localiser.*
> - *½ dot deviation from course (non-precision).*
> - *5 deviations from NDB course.*
> - *100 ft above or 50 ft below MDA. Prior to runway in sight, any deviation below MDA requires an immediate correction.*
> - *Plus 10 kts, minus 0 knots deviation from target speed.*
> - *Descent rate exceeds 1,000 fpm on final approach*
>
> *Below 500 feet (VMC) and 1,000 feet (IMC), it is policy to execute a go around if the aircraft exceeds any of the maximum deviation parameters during this phase.'*

The operator also included comprehensive procedures for approach monitoring and the duties and responsibilities for the Pilot Flying (PF) and the Pilot Monitoring (PM).

The approach window was also defined with its associated requirements as follows:

> *'1.120. Approach Window*
>
> *In order to facilitate a stabilized approach, an approach window is established as a point 500 ft above the runway elevation (VMC), 1000 ft above the runway elevation (IMC), on centreline and glide slope. At this point the aircraft must be configured to land, unless an abnormal procedure requires otherwise, and must not exceed the parameters listed in Paragraph 18.116., Flight Deviation Parameters.'*

Aircraft information

At the time of the accident the aircraft had achieved 1,888 flight cycles and 3,961 flying hours. The most recent significant maintenance inspection was a '24 Month Check', which was conducted in Switzerland and completed on 3 October 2013 when the flights/hours figures were 1,831 and 3,779 respectively. Since then, maintenance activity consisted of daily and weekly inspections. The only defect recorded in the Technical Log was that the Captain's microphone switch had become stuck in the 'mask' position, as noted earlier. This item had been deferred in accordance with the aircraft Minimum Equipment List (MEL).

Accident site details

Examination of the airfield on the approach side of Runway 22 threshold revealed that the aircraft had successively struck the Runway 22 ILS localiser monitor aerial and the Runway 04 localiser aerial array. These structures were located only 5 to 6 m apart and the damage can be seen in Figure 2.

Figure 2

View of damaged monitor aerial and ILS localiser array

The monitor aerial consisted of a tower approximately 5.5 m high, which was constructed from lightweight fibreglass material and supported a coaxial aerial cable. The 4.2 m high ILS array comprised a series of 24 stanchions, each carrying 14 horizontally-orientated dipoles, which consisted of aluminium alloy tubes covered with orange plastic sheathing. The stanchions were arranged equidistant from each other, 12 either side of the runway centreline.

It was apparent that the aircraft had broken off the top of the monitor tower before striking the dipoles on stanchions 13 and 15, which placed the aircraft slightly right of the runway centreline. The latter impact had dislodged eight of the dipoles, which were scattered over the grass towards the runway.

Some tyre marks were observed on an 85 m paved extension that preceded the 'piano key' marks at the start of the runway. These indicated that touchdown had been made right landing gear first, left of the runway centreline and approximately 40 m from the start of the paved extension. This was approximately 520 m from the start of the touchdown zone.

ILS unserviceability

ATC recorded the aircraft landing at 0325 hrs UTC and at 0328 hrs were advised that Runway 22 ILS had suffered a 'technical fault'. An engineer was despatched to investigate and the ILS was downgraded from CAT III to CAT I; the Airfield Operations Duty Manager issued a NOTAM to that effect at 0345 hrs.

Despite the damage to the localiser aerials, the Runway 04 ILS remained serviceable at CAT III, although it was taken out of service at 0745 hrs prior to the commencement of repairs.

Examination of the aircraft

It was apparent that the aircraft's left landing gear had struck the monitor aerial and the localiser array, with the left wing underside ahead of the gear showing evidence of scratches and orange paint transfer. Most of the scratches were superficial, although there was a significant gash approximately 300 mm in length and 5 mm deep. However, the skin had remained intact, with no fuel seepage. The leading edge was unmarked.

The left landing gear door had sustained a significant impact on its leading edge; the appearance and dimensions of the damaged area suggested this had been made by one or more of the dipoles. The geometry of the main landing gear is such that it is probable that the tyres also made contact with the ILS equipment, although they bore no obvious marks. It was noted that a hydraulic brake line, located close to the bottom of the leg, between the wheels, had sustained some distortion during the impact, although there were no leaks.

After the on-site examination, the aircraft was cleared for the short flight to the aircraft manufacturer's UK facility at Luton Airport, where temporary repairs were effected. The aircraft was then flown to the manufacturer's main base in Savannah, Georgia, USA, for annual inspection and permanent repairs in October 2014.

Recorded data

Fault history database (FHDB)

The aircraft was equipped with the Honeywell Primus Epic Modular Avionic system, which is used across a number of aircraft types. Its function is to integrate the systems and sub-systems that supply the aircraft with navigation, communication, autoflight, indicating, recording and maintenance capabilities.

In the subject aircraft the system consisted of three Modular Avionic Unit (MAU) cabinets, each containing processors, and functional modules, which included input/output modules that provided interfaces with the various aircraft systems. There was also a terrain awareness warning system (TAWS), which comprised two Enhanced Ground Proximity

Warning modules (EGPWM). A Central Maintenance Computer (CMC) Module provided the integrated maintenance and aircraft condition monitoring function. Its purpose was to collect active faults from member systems, and compile a Fault History Database (FHDB). The latter was downloaded and found to contain information for every flight from when the aircraft was returned to service after the 24-month maintenance check.

Analysis of the FHDB revealed that on every approach, a series of *'Voice Activity Fail'* messages was generated, which were associated with EGPWS Warning Modules 1 and 2. However, there were no audio alerts and no messages displayed on the Crew Alerting System (CAS). The aircraft and avionic manufacturers were asked to provide assistance in understanding these messages with a view to determining whether they represented a malfunction of the EGPWS system.

The system is designed such that, under normal power-up conditions, EGPWS Module 1 would have priority over Module 2. Module 2 would gain priority in the event of a fault with Module 1. Although only one module has priority, both modules monitor the same input conditions and would simultaneously execute the same functions. Thus a genuine EGPWS failure on every flight would require the extremely improbable scenario of a defect occurring within each warning module as well as both input/output modules.

In the event of an alert needing to be issued, the EGPWM issues a voice request; this is processed by an audio driver within an audio control panel, which is another system component. The lack of a response to such a request results in a *'Voice Activity Fail'* message. However, the manufacturer stated that, by design, the '*Voice Activity Fail*' functionality cannot inhibit any EGPWS modes. The CVR indicated that the altitude call-outs were being generated as normal during the final approach to the runway on the accident flight.

During the subsequent flight to Luton a Mode 5 (ie 'Glideslope') warning was generated during the approach. Analysis of the associated DFDR data indicated that this was genuine. In addition, although the EGPWM issued the voice requests for the glideslope alerts and altitude call-outs, *'Voice Activity Fail'* messages were also logged. The reason for this was not established. However, Honeywell, after reviewing all the available data, stated that there were no systemic issues and that the TAWS system had otherwise performed as designed.

After the aircraft had returned to the manufacturer's facility in the USA, the software was successfully reloaded into the EGPWS Modules. It was considered that this operation could not have been achieved if there had been a hardware problem.

The aircraft returned to service following repairs and the manufacturer subsequently conducted further downloads of the FHDB. This revealed that the *'Voice Activity Fail'* problem had persisted. It is thought that there may be a common interface fault, possibly on an input/output module, that could result in both EGPWMs falsely reporting a problem. Consequently, a number of MAU modules were removed from the aircraft for further testing.

FDR/CVR information

The flight data recorder (FDR) and cockpit voice recorder (CVR) were removed from the aircraft, downloaded and the recordings analysed by the AAIB.

Figure 3 shows the salient parameters recorded on the FDR during the approach and touchdown. The figure starts with the aircraft about 12 nm from Runway 22 on a westerly heading at 3,750 ft amsl, 179 kt IAS (V_{APP} + 48), Flaps 20, with a descent rate of just over 1,150 ft/min. Autopilot and autothrust were also engaged, with 'heading hold' and 'vertical speed' flight director modes selected.

The aircraft then turned left and levelled off at 3,000 ft amsl (2,500 ft agl), intercepting the localiser at about 11 nm, and the glideslope at about 8.5 nm. As the aircraft descended through 1,600 ft agl on the glideslope, with 181 kt IAS, Flaps 40 was briefly selected before returning back to Flaps 20. The airspeed then reduced to about 165 kt and Flaps 40 was reselected; however, the aircraft was now above the glideslope where it remained (mostly between 1 and 2 dots deviation) until about 300 ft agl and 1 nm from the runway, just as the airspeed slowed to 131 kt (V_{APP}).

The aircraft continued to decelerate and then descended below the glideslope, reaching 4 dots deviation as the aircraft collided with the localiser antenna at 19 ft agl. The airspeed at this point was 115 kt. Main landing gear touchdown occurred seven seconds later.

Automatic radio altimeter height call outs were given at 1,000, 400, 300, 200, 100, 50, 40, 30, 20 and 10 feet. Some of these, together with autopilot (AP), autothrust (AT) and flight director (FD) vertical and lateral use during the approach and descent, are summarised in the following table:

Distance to Runway 22 (nm)	Radio Height (feet agl)	IAS (kt)	UTC	Event
4.99	1612	178	03:22:56	AP disengaged
4.10	1387	167	03:23:14	AP briefly engaged
3.58	1388	165	03:23:25	AT disengaged
3.07	1234	161	03:23:39	AP briefly engaged
2.43	1000	167	03:23:52	'1000'
1.79	690	152	03:24:11	FD-vert: *Glideslope* to *GoAround* FD-lat: *AppLOC* to *HdgHold*
1.66	647	150	03:24:13	FD-lat: *HdgHold* to *Lnav(FMS)*
1.02	300	129	03:24:31	'300'
0.90	179	130	03:24:40	'APPROACHING MINIMUMS'
0.64	141	128	03:24:45	'MINIMUMS'
0.26	20	116	03:24:56	'20'
0.25	19	115	03:24:57	Collision with localiser
0.13	10	112	03:24:59	'10'
0	3	108	03:25:04	Mainwheel touchdown
0	0	103	03:25:06	Nosewheel touchdown

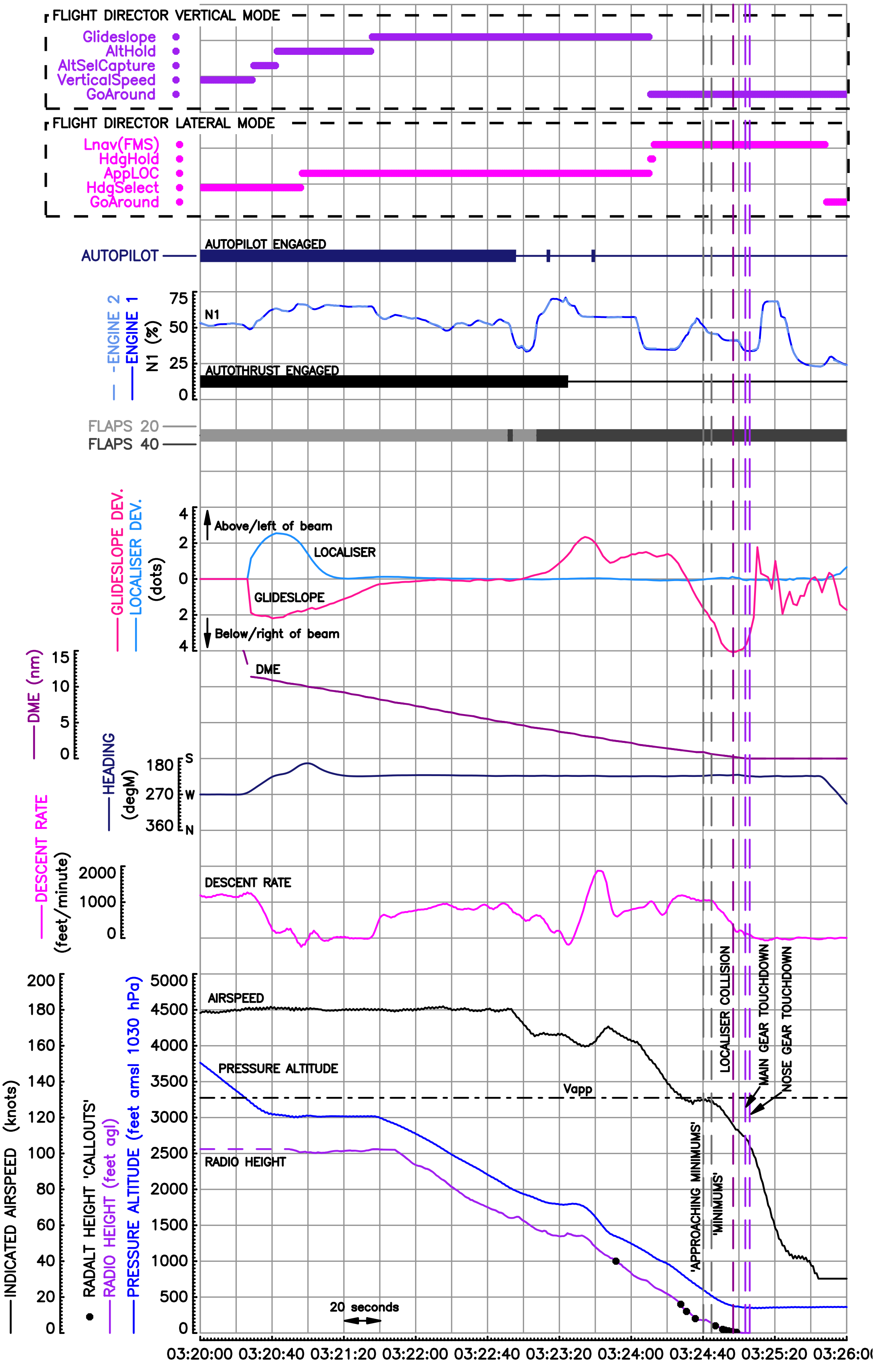

Figure 3

Salient recorded flight data for approach and landing at Stansted

Analysis

The aircraft struck the ILS aerials and touched down more than 500 m short of the touchdown zone as a result of descending below the glideslope. There were no EGPWS warnings, which initially posed questions as to the serviceability of the TAWS system. Although some messages in the FHDB could not be explained, it was concluded that the system had functioned correctly up to the point where the go-around mode was selected, which would have inhibited the glideslope alerts. This was reinforced by the genuine Mode 5 alert that was issued by the system during the subsequent flight from Stansted to Luton.

The crew were properly licensed and qualified to conduct the flight. In their pre-flight briefing and planning they had identified the possibility of fog at Stansted and had nominated Manchester as a suitable diversion. The transit flight to Stansted was uneventful and the commander's unserviceable radio selector panel was not relevant to the accident.

The RVRs in the ATIS reports and those passed to the crew with their landing clearance were below the CAT I minimum RVR of 550 m. The approach should not have been commenced as the UK ANO requirements did not allow the crew to descend below 1,000 ft aal in these conditions and the company GOM procedures did not permit an approach to be made in such conditions.

During the descent towards Stansted Airport, the crew reported that prior to descent they had briefed the arrival and missed approach should it be necessary. The autopilot captured the localiser and the glideslope for Runway 22, but the selection of full flap, above the flap limiting speed, appears to be the start of a chain of events which destabilised the approach.

The disengagement of the autopilot and autothrust led to the aircraft levelling and rising above the glidepath, which was notified to the crew by ATC. Whilst correcting the flightpath to regain the glideslope, two attempts were made to re-engage the autopilot, but these were unsuccessful so the commander continued to hand fly the aircraft. The reason for the unsuccessful re-engagements was not determined. The aircraft flew above the glideslope where it remained (mostly between 1 and 2 dots deviation) until about 300 ft agl and 1 nm from the runway, just as the airspeed slowed to 131 kt (V_{APP}). At a height of 691 ft the go-around mode was selected, but the commander continued visually towards the runway, passing through the glidepath at about 300 ft at 1.0 nm. The reason for the change to go-around mode could not be determined, but it was significant in that glideslope deviation alerts would no longer have been provided. The aircraft continued to decelerate and then descended below the glideslope, reaching 4 dots deviation as the aircraft collided with the localiser antenna at 19 ft agl.

The glidepath deviations were outside the stabilised approach criteria and when combined with the reducing airspeed below V_{APP}, a go-around should have been flown.

Although the approach and runway lights were visible to the pilots, the PAPIs were not and therefore the approach path angle was a matter of judgement. Apart from the normal advisory callouts, the EGPWS did not alert the crew to the deteriorating situation as the aircraft began to undershoot the runway because the go-around mode had been selected.

The radio altimeter height 'callouts', combined with the visual perspective of the runway lights, provided the cues to flare the aircraft.

The fact that the pilots could see the runway and approach lighting caused them to believe that, as long as they remained visual with these landing references, they would comply with their company procedures and thus could continue their approach.

Conclusion

The accident occurred as a result of the approach becoming destabilised and the pilots attempting to regain the correct glidepath at a late stage, rather than performing a go-around. Descending below the glidepath at such a late stage caused the aircraft to collide with the ILS aerials.

The RVR was below the 550 m minima required for the crew to commence a CAT I approach.

ACCIDENT

Aircraft Type and Registration:	i) Denney Kitfox, G-TOMZ ii) Cessna F177RG, G-AZTW
No & Type of Engines:	i) 1 x Rotax 912 UL ii) 1 x Lycoming IO-360-A1B6
Year of Manufacture:	i) 2001 ii) 1972
Date & Time (UTC):	23 September 2014 at 0728 hrs
Location:	Near St Neots, Bedfordshire
Type of Flight:	i) Private ii) Private
Persons on Board:	i) Crew - 1 Passengers - None ii) Crew - 1 Passengers - None
Injuries:	i) Crew -1 (Fatal) Passengers - N/A ii) Crew - None Passengers - N/A
Nature of Damage:	i) Aircraft destroyed ii) Damage to engine, propeller, fuselage underside and horizontal tailplane
Commander's Licence:	i) Private Pilots Licence (Medical declaration) ii) Private Pilots Licence (JAA Class 2 medical certificate)
Commander's Age:	i) 46 years ii) 56 years
Commander's Flying Experience:	i) 990 hours (of which approximately 200 were on type) Last 90 days - 36 hours Last 28 days - 4 hours ii) 1038 hours (of which 604 were on type) Last 90 days - 11 hours Last 28 days - 7 hours
Information Source:	AAIB Field Investigation

Synopsis

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

History of the flights

Denney Kitfox G-TOMZ

The pilot, who owned the aircraft, took off from his private strip at 0752 hrs, and departed on a southerly track towards Sandy Airfield. This was a route he flew regularly, when the weather permitted, as a means of getting to his place of work. He normally flew the route at between 2,000 ft and 4,000 ft, at a speed of between 70 kt and 80 kt. At approximately 0725 hrs he called on the Microlight Common Frequency to inform Sandy Airfield traffic that he was approaching the airfield.

Cessna F177RG Cardinal, G-AZTW

At around 0720 hrs, the pilot of G-AZTW, who was a co-owner of the aircraft, took off from Fowlmere Airfield for Sywell Aerodrome. This was a route he also flew regularly, when the weather permitted, as a means of getting to his place of work. The flight was uneventful until he was approaching the south of St Neots. The pilot reported he was looking out and using ground features to determine he was on track. He was in Class G[1] airspace, and recalled cruising at approximately 2,700 ft, at a speed of 130 kt, and on a heading of approximately 285°. He was listening to the Luton Approach frequency, and his transponder was set to the appropriate 'Listening-out squawk[2]' for Luton.

The pilot recollected suddenly seeing a red light aircraft, with a high wing and a single engine, that he thought was climbing towards him. It was positioned between two and three o'clock, slightly below him, at a distance of 15 to 20 ft. He considered a collision was imminent and instinctively pulled the control column back and turned it to the left. The pilot of G-AZTW thought that the other pilot had not seen his aircraft because G-TOMZ did not appear to have taken any avoiding action.

The pilot of G-AZTW felt and heard an impact, and his aircraft pitched nose-down severely. He applied full aft elevator, but his aircraft did not initially respond. He then transmitted a Mayday call and started to trim the elevator fully back. Using full control input and engine power, he was able to regain limited control of his aircraft. Ahead of him he could see Bedford Aerodrome and, having informed Luton ATC of his intentions, he made a straight-in approach to Runway 26 and landed safely. Although shaken, he was uninjured. After landing he telephoned Luton ATC and provided further details.

G-TOMZ was located shortly afterwards by the emergency services, in a field 2.7 nm to the south of St Neots. The pilot had sustained fatal injuries.

Eyewitness information

An eyewitness was in her garden when she saw an aircraft which appeared to be banking steeply before entering a steep dive. The aircraft started to rotate and the speed of the rotation seemed to increase as it descended, before it disappeared from view behind bushes. The witness saw no other aircraft in the sky at the same time.

Footnote

[1] See the section *'Class G airspace', below.*

[2] Listening-out Squawk codes, or frequency monitoring SSR codes are allocated for aircraft operating around 10 major UK airfields. AIP ENR 1.6 2.2.5.6 contains the details.

Pilot information

The pilot of G-TOMZ held a Private Pilot's Licence, rated for microlights, originally issued in 1994. The medical declaration[3] was in date and countersigned by a General Practitioner. The pilot was required to wear corrective lenses, and evidence of two pairs of glasses were found in the wreckage. The pilot was in current flying practice as evidenced by the Sandy Airfield Private Flight Log Sheet, which showed he had flown into Sandy Airfield five times during the preceding five weeks.

The pilot of G-AZTW held a Private Pilot's Licence, originally issued in 1986. His Class 2 medical certificate included the limitation that he must wear corrective lenses and he was in current flying practice.

Aircraft information

G-TOMZ

The Denney Kitfox is a two-seat high-wing monoplane with tail wheel landing gear. The aircraft is of tubular alloy, plywood and fabric construction, with a wing span of 9.75 m. G-TOMZ was built in 2001 and was fitted with a Rotax 912 UL engine. The aircraft had a valid Permit to Fly. It was coloured predominantly white with red wings and markings, as shown in Figure 1.

Figure 1

Image of Denney Kitfox G-TOMZ (with kind permission of Peter Olding)

Footnote

3 CAA Official Record Series 4, No 995 allows the medical requirements for a PPL(A) rated for microlights to be met by a pilot's self declaration.

G-AZTW

The Cessna F177RG Cardinal is a four-seat, high-wing monoplane with a retractable tricycle landing gear. It was built in 1972 and was fitted with a 200 hp Lycoming engine. The aircraft had a valid Airworthiness Review Certificate. It was predominantly white with red and blue markings, and had an anti-collision light. Its typical straight-and-level cruising airspeed is around 120 to 140 kt.

Wreckage and wreckage site of G-TOMZ

Most of the wreckage was located in a small area in a stubble field. The vertical and horizontal tailplane were largely intact but the wing and fuselage were severely disrupted. Both the wing-mounted fuel tanks were badly damaged, and there was a smell of fuel. There was no evidence of fire.

Several parts of the right wing were located over 250 m from the main wreckage. The right wing tip fairing, which is red, had white scuff marks. There was a 1.6 m long piece of the alloy leading edge spar tube, one end of which appeared to have failed in overload and the other appeared to have been cut through at an angle of approximately 35°, just inboard of the wing tip.

Damage to G-AZTW

G-AZTW landed successfully at Bedford Aerodrome. There was a 12 cm wide scuff mark on one blade of the propeller, and a 50 cm long dent with red witness marks in the left lower part of the cowling, see Figure 2. Several small pieces of aircraft structure from G-TOMZ were removed from the nose gear door of G-AZTW. There were some scuff marks along the fuselage underside. The landing gear was down, with no evidence of any witness marks that might have occurred had the gear been down during the collision. There was extensive damage to approximately 75% of the underside of the left horizontal tailplane, and a piece of the horizontal tailplane tip fairing was found approximately 500 m from the main wreckage of G-TOMZ.

Figure 2
Images of G-AZTW at Bedford Aerodrome

Assessment of damage to both aircraft

By comparing the damage and the witness marks on both aircraft it appears that the initial impact was between the rotating propeller of G-AZTW and the right wing tip of G-TOMZ. The damage to the lower left of the engine cowling on G-AZTW suggests that the propeller was around the five o'clock position when this occurred. Thus G-AZTW was slightly higher than G-TOMZ at the time of the collision resulting in the damage to the lower fuselage and horizontal tailplane of G-AZTW.

Approximately 40% of the outboard right wing of G-TOMZ was found over a wide area, which suggests that this damage occurred in mid-air. It is likely that the aircraft would not have been capable of normal flight with such damage.

Limitations of lookout

Maintaining an effective lookout for aircraft and other hazards is a prime task for a pilot. It is of particular importance when flying in uncontrolled airspace.

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

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

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

Two aircraft on a collision course, which are maintaining constant tracks, will maintain a constant relative bearing to each other until the moment of impact. The colliding aircraft will therefore appear in the same place unless the pilot makes a head movement. As the colliding aircraft is not moving relatively, it does not necessarily attract the attention of the peripheral vision system. The rate of increase in retinal size of the approaching aircraft is not linear and the image stays relatively small until very shortly before impact. Additionally, small targets may be hidden behind door frames or struts, or in a blind spot,[4] until close to collision. For these reasons pilots are taught not just to look around them, but to make positive head movements as they do so.

The Australian Transport Safety Bureau (ATSB) explored visual acuity in its research report, 'Limitations of the See-and-Avoid Principle', published in April 1991[5]. The report considered the angular size that the retinal image of an aircraft would have to be before it was identifiable and suggested a threshold of 0.2º, in optimal conditions, up to approximately 0.5º in more realistic sub-optimal[6], conditions.

The effectiveness of visual air-to-air acquisition also depends on the contrast of an aircraft with its background[7]. Increased contrast improves visual acquisition but contrast degrades exponentially with visual range. If contrast reduces to approximately 5% the target disappears. It was not possible to account for contrast during this investigation, so only the size of the target was considered.

In 1983 the FAA[8] issued an Advisory Circular detailing the amount of time it takes for a pilot to recognise an approaching aircraft and execute an evasive manoeuvre. The circular detailed the time taken: to see an object, to recognise it is an aircraft, to become aware it is on a collision course, to decide on the appropriate avoiding action, to make the necessary control inputs and for the aircraft to respond. The publication indicated it could take around 12.5 seconds to complete these actions.

Meteorological information

At the time of the accident, England was under the influence of high atmospheric pressure, with settled conditions and a light south-westerly airflow. There was widespread early morning mist reported, which was clearing to give hazy conditions, and visibility was reported to be approximately 7,000 to 8,000 m. The location of the accident was close to the northern edge of an area of stratocumulus cloud, with a base at approximately 4,500 ft to the south of this. Sunrise was at 0549 hrs and at the time of the accident the sun would have been low in the sky to the south-east. This would have adversely affected into-sun visibility. Under the layer of stratocumulus further south, the sun's position would not have affected visibility. A Met Office aftercast indicated that the wind at 2,400 ft was from 260° at 10 kt.

Footnote

[4] Blind spots are a characteristic of the human eye. The blind spot is located where the optic nerve connects to the eye. If something obstructs one eye's view (such as aircraft structure) the viewed object may be in the remaining eye's blind spot, causing it to disappear.
[5] ISBN 0 642 16089 9 Reprinted November 2004.
[6] With reduced contrast.
[7] Project Report ATC-152. Unalerted air-to-air acquisition. J. W. Andrews 26 November 1991.
[8] U.S. Department of Transportation, Federal Aviation Administration (FAA), Advisory Circular AC 90-48C, Pilots' Role in Collision Avoidance (18 March 1983), Appendix 1.

Recorded information

Recorded radar information was available for both aircraft, with primary and secondary (Mode A and C) recorded for G-AZTW and primary for G-TOMZ. Figure 3 provides the radar tracks of the aircraft. Figure 4 plots the positions of both aircraft commencing at a separation of just over 1 nm, with the relative positions identified at four second intervals and angular sizes of 0.2° and 0.5° when viewed from either aircraft. For clarity, the tracks have been illustrated in Figure 4 rather than the actual radar tracks.

Prior to the collision, G-TOMZ had been maintaining a southerly track of about 180° T at a groundspeed of 64 kt and G-AZTW a track of about 298° T at an altitude of approximately 2,400 ft amsl and at a groundspeed of 118 kt. As the two aircraft approached, they remained on a constant bearing with each other at a closing speed of approximately 157 kt. Assuming a wind from 260° at 10 kt, G-TOMZ would have appeared about 24° to the right of G-AZTW, and G-AZTW would have appeared 50° to the left of G-TOMZ.

Impact is estimated to have occurred at 0728:29 hrs. The main wreckage of G-TOMZ was located approximately 0.15 nm from where the two radar tracks intersected.

Table 1 contains the angular size[9] of each aircraft as they approached each other.

TIME TO COLLISION (s)	RANGE (nm) / (m)	ANGULAR SIZE of G-TOMZ when observed from G-AZTW (º)	ANGULAR SIZE of G-AZTW when observed from G-TOMZ (º)
24	1.05 / 1,940	0.14	0.17
20	0.87 / 1,620	0.17	0.20
17.5	0.76 / 1,420	0.20	0.23
16	0.70 / 1,295	0.22	0.26
12	0.52 / 970	0.29	0.34
8	0.35 / 650	0.43	0.52
7	0.30 / 565	0.50	0.59
4	0.17 / 325	0.87	1.03

Table 1

Angular size from 24 seconds before the collision

Immediately following the collision, G-AZTW descended rapidly for about 16 seconds at an average rate of 1,700 fpm before recovering at about 1,950 ft (see Figure 5). It then climbed to about 2,350 ft before descending to land on Runway 26 at Bedford Aerodrome.

Footnote

[9] This is based on the average of the span, length and height of the aircraft.

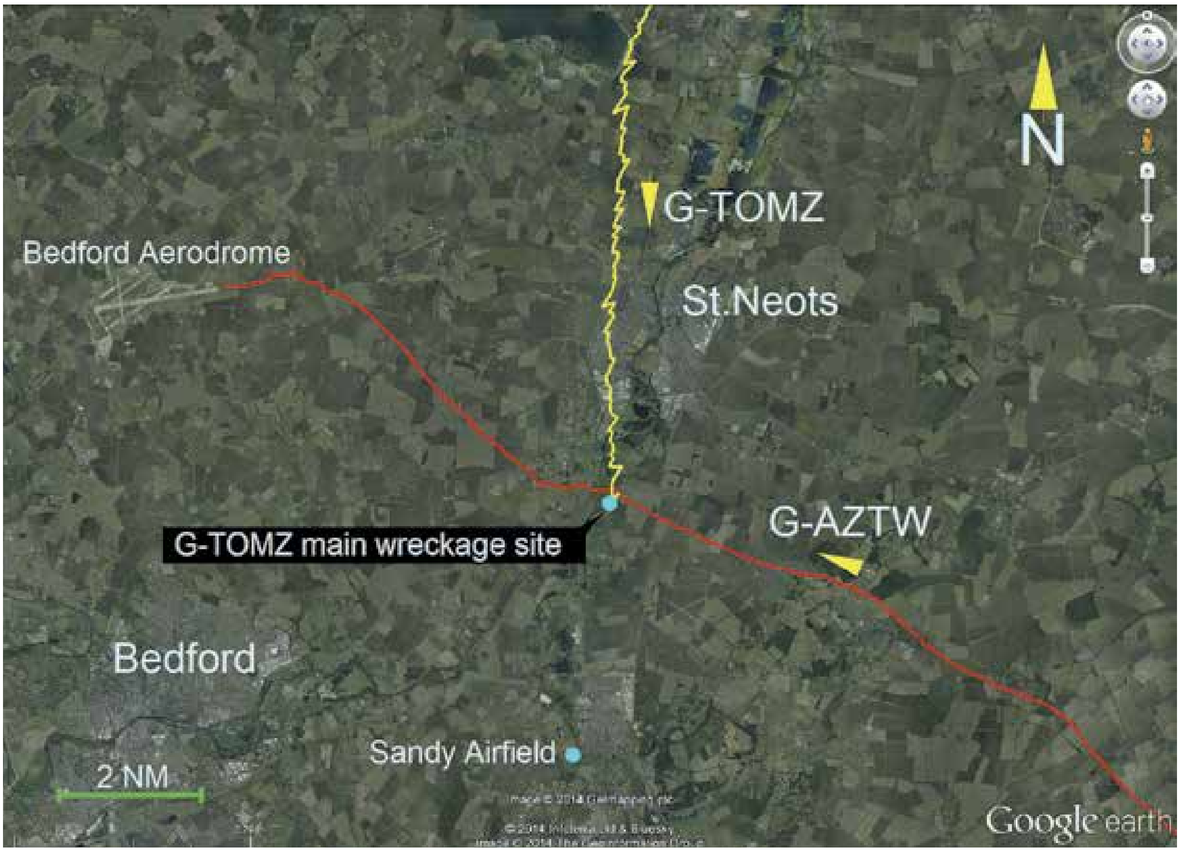

Figure 3
Radar tracks of G-TOMZ and G-AZTW

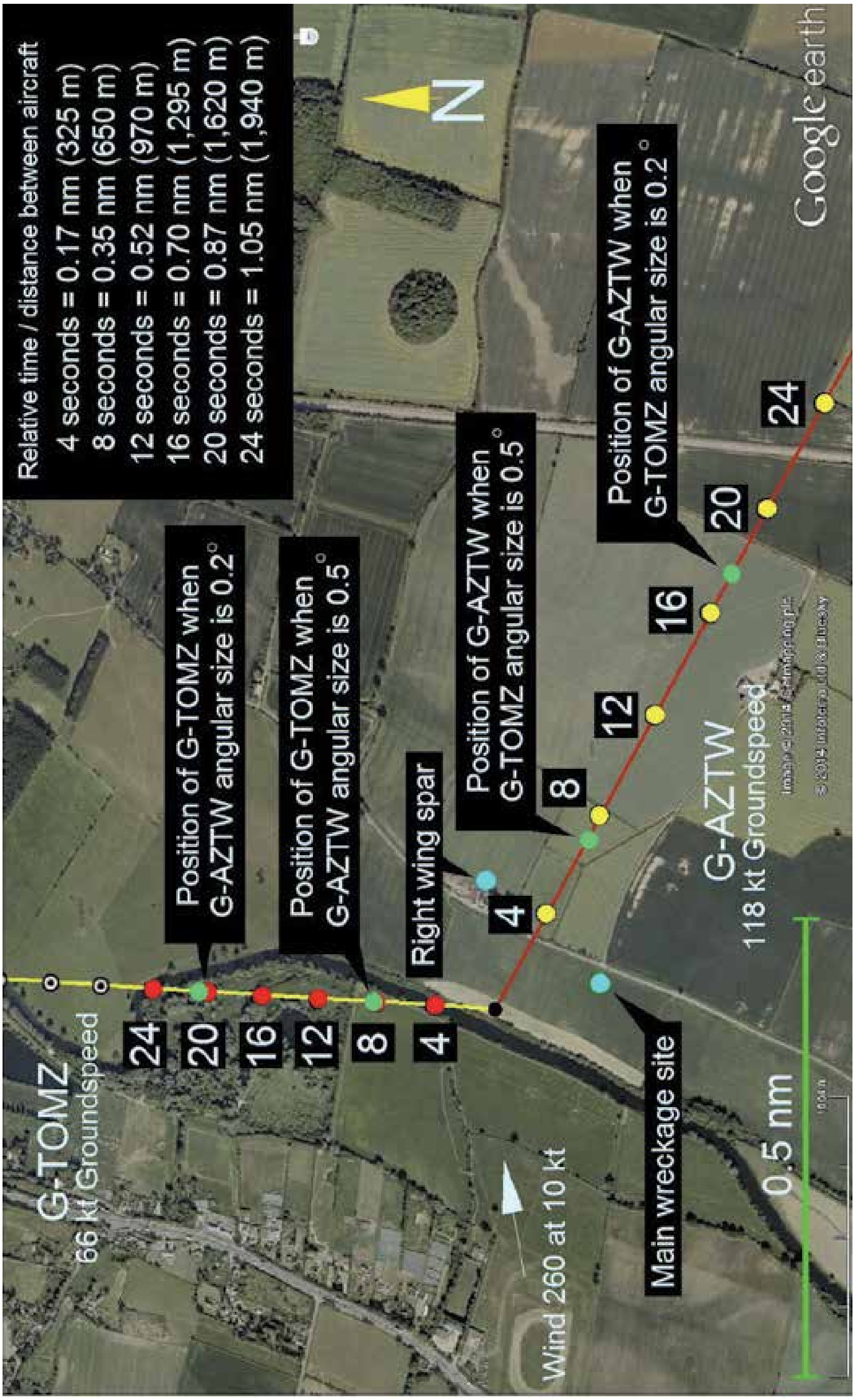

Figure 4

Relative positions of G-TOMZ and G-AZTW prior to collision

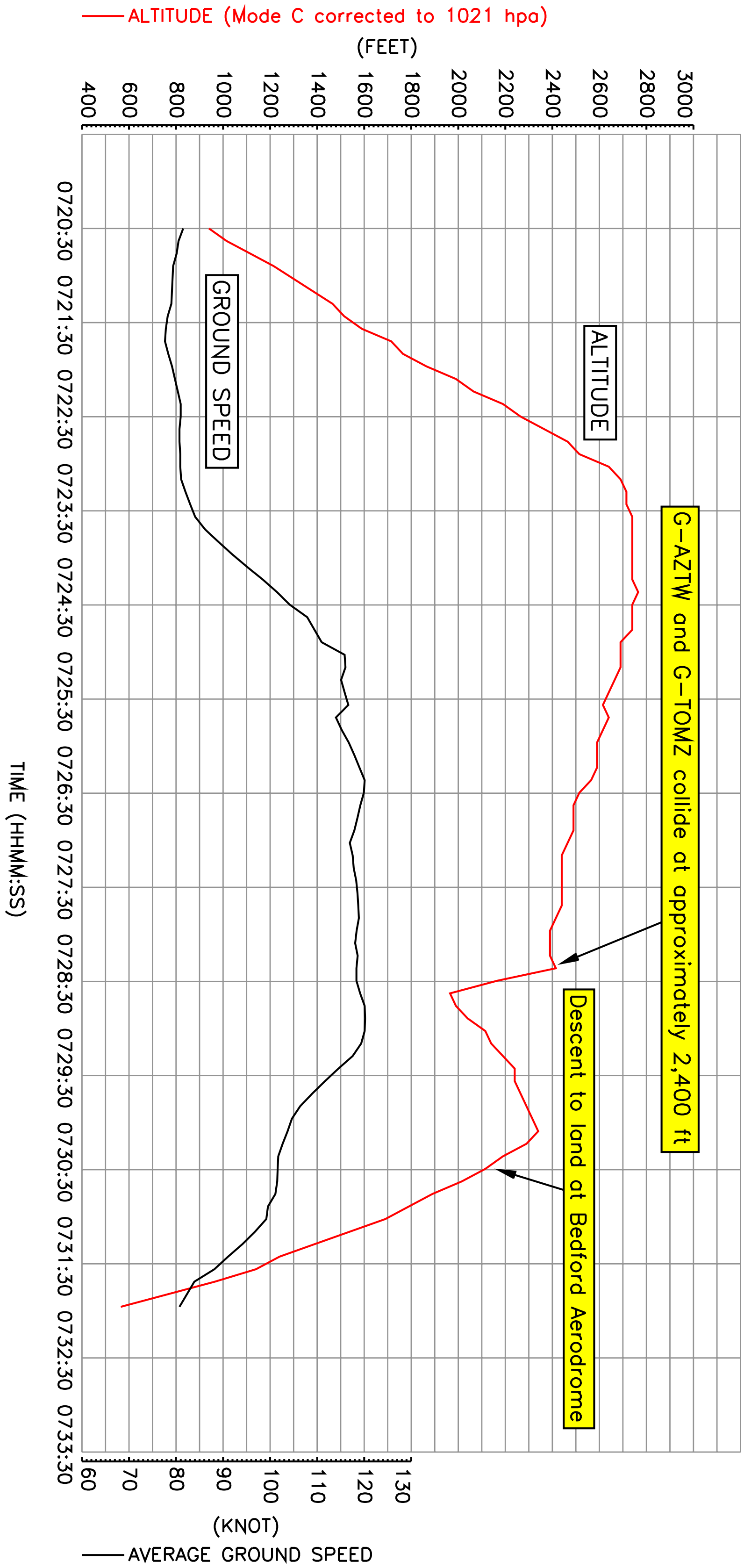

Figure 5

G-AZTW Altitude and groundspeed

View from the respective cockpits

An assessment was made of the likely views that each pilot would have had when looking in the direction of the other aircraft. See Figures 6 and 7. It was determined that G-AZTW had a large door frame to the right side of the cockpit; G-TOMZ had a wingstrut outside the left window.

Figure 6

Pilot's eye view from a F177RG in the direction of G-TOMZ

Figure 7

Pilot's eye view from a Denney Kitfox in the direction of G-AZTW

Medical and pathological information

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

Class G airspace

Airspace over the UK is divided into several classes, described in the UK Aeronautical Information Publication (UK AIP).[10]

The airspace in which the aircraft were operating at the time of the collision was classified as Class G airspace, which is uncontrolled, and includes all UK airspace which is not either controlled or advisory airspace.

Pilots operating in Class G airspace are not obliged to seek an air traffic service, and ATC instructions to pilots are not mandatory. Although pilots are free to seek a service from ATC, controllers cannot guarantee to achieve de-confliction minima due to the unknown nature of the Class G air traffic environment.

The UK AIP states:

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

Rules of the air

The Rules of the Air Regulations 2007 are applicable to flights within the United Kingdom. In respect of powered aircraft, Regulation 9 (3) states:

> *'… when two aircraft are converging in the air at approximately the same altitude, the aircraft which has the other on its right shall give way.'*

Regulation 8(1) states:

> *'… it shall remain the duty of the commander of an aircraft to take all possible measures to ensure that his aircraft does not collide with any other aircraft.'*

Footnote

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

Previous mid-air collisions

The CAA database showed that, in the UK in the 10 years before this accident, there were 22 mid-air collisions resulting in 16 fatalities[11].

Collision avoidance

The primary method of detecting other aircraft in uncontrolled airspace is 'see-and-avoid', where pilots conduct a visual scan to detect other traffic. 'See-and-avoid' can be enhanced by the use of an electronic aid, either air or ground based, to provide range, bearing and (possibly) height information. Such a method is called 'alerted see-and-avoid'. Studies have shown that this method can be eight times more effective[12] than 'see-and-avoid'.

There are several TCAS and non-TCAS aircraft-based electronic aids available, each of which has its limitations. These aids will only provide warnings of other aircraft that are fitted with compatible equipment. A hazard of relying on such electronic aids is that a pilot may concentrate on aircraft that the system has detected to the detriment of looking for other aircraft that do not have the equipment fitted.

The UK Airprox Board (UKAB)[13] has recommended that the CAA should promote the production, and mandate the use of a lightweight transponder. In response, the CAA considered Mode S transponders to be the most appropriate equipment, but following consultation with the aviation community, decided not to mandate their use in uncontrolled airspace. The principal arguments against such transponders are their relatively high power consumption, the cost, and the weight penalty. These arguments are not as strong for equipment such as FLARM[14], which is not utilised by ground-based radars, but intended to alert pilots to nearby aircraft. For such systems to be effective, it would be necessary for all aircraft operating in uncontrolled airspace to be fitted with compatible equipment.

Automatic Dependant Surveillance Broadcasting (ADS-B) collision avoidance trial

Many aircraft already carry transponders that are capable of transmitting GPS sourced positional information via ADS-B. Until recently the CAA required such functionality to be disabled, unless the GPS source was certified. Certified GPS sources have been considered too expensive for the GA community to use.

NATS,[15] is conducting a trial with the AOPA[16], Trig Avionics and Funke Avionics, which uses a non-certified GPS source, connected to a transponder. The aim of the trial is to understand whether the performance of uncertified GPS devices, in conjunction with ADS-B, can be

Footnote

[11] For aircraft under 5,700 kg, a General Aviation Safety Council (GASCo) study over a 26 year period has shown that in the UK 6% of fatalities were caused by mid-air collisions. This compares with almost 25% attributed to loss of control in VMC and 12% caused by controlled flight into terrain.
[12] Unalerted Air-to-Air visual Acquisition Andrews MIT 1991 Project Report ATC-152.
[13] UKAB recommendation 186/05-02.
[14] FLARM is a device that provides a warning, and positional information, of other similar devices it detects in close proximity. FLARM does not increase an aircraft's electronic conspicuity to Air Traffic Service (ATS) providers, unlike mode A, C or S Transponders. More information is available at www.flarm.com
[15] NATS is the UK's national ATS provider.
[16] AOPA Aircraft Owners and Pilots Association, http://www.aopa.co.uk/

used to deliver safety benefits. Possible applications include collision avoidance warnings in the cockpit, enhanced situational awareness, and advanced functions such as synthetic traffic information spoken directly into the pilot's headset.

A supplementary initiative is to introduce a low powered ADS-B transceiver called LPAT (Low Powered ADS-B Transceiver). It is intended that this will be an affordable, lightweight, carry-on device, to provide enhanced awareness of other aircraft.

Analysis

Recorded information indicates that the aircraft approached each other in steady flight, and there was no evidence to indicate that either was in difficulty prior to the collision. The accident occurred in Class G airspace, with neither aircraft in receipt of an ATC service, so the only way to avoid a collision was the use of see-and-avoid techniques. The following factors may have contributed to neither pilot seeing the other aircraft until too late to avoid a collision:

- Each aircraft had little or no relative movement when viewed from the cockpit of the other making them difficult for each pilot to detect.
- Both pilots were navigating visually, so their lookout would have been focussed primarily in the direction they were travelling. The pilot of G-TOMZ was 3.6 nm North of Sandy Airfield and so it's likely his attention was focussed on his arrival into the circuit pattern.
- There was airframe structure in both aircraft that may have prevented the pilots from seeing each other.
- The position of the sun, low in the sky to the south-east, could have made detection of G-AZTW more difficult for the pilot of G-TOMZ.

Research by the ATSB showed that in optimal conditions G-TOMZ might have been visible to the pilot of G-AZTW approximately 17.5 seconds before the collision; G-AZTW may have been visible to G-TOMZ approximately 20 seconds before the collision.

In more realistic sub-optimal conditions, G-TOMZ should have been visible for approximately 7 seconds, and G-AZTW should have been visible for approximately 9 seconds before the collision. FAA research on collision avoidance indicates this would have provided insufficient time for either pilot to take effective avoiding action.

Regulation 9 of the Rules of the Air Regulations, which would have required the pilot of G-AZTW to give way in this case, could only have been complied with if the pilot had seen G-TOMZ in sufficient time for him to take appropriate avoiding action.

'See-and-avoid' is a not a perfect technique for preventing mid-air collisions due to the limitations of the human eye. Technology may provide an affordable enhancement which could reduce the number of mid-air collisions. Until then, whenever possible, pilots should be encouraged to make use of transponders in conjunction with a radar service, and to maintain an active lookout.

Conclusion

The accident occurred because the pilots did not see each other's aircraft in time to take effective avoiding action.

AAIB correspondence reports

These are reports on accidents and incidents which were not subject to a Field Investigation.

They are wholly, or largely, based on information provided by the aircraft commander in an Aircraft Accident Report Form (AARF) and in some cases additional information from other sources.

The accuracy of the information provided cannot be assured.

SERIOUS INCIDENT

Aircraft Type and Registration:	Beechcraft 300 Super King Air, SE-KOL	
No & Type of Engines:	2 Pratt & Whitney Canada PT6A-60A turboprop engines	
Year of Manufacture:	1989 (Serial no: FA-189)	
Date & Time (UTC):	13 November 2014 at 2030 hrs	
Location:	Farnborough Airport, Hampshire	
Type of Flight:	Commercial Air Transport	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Flap motor overheated	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	38 years	
Commander's Flying Experience:	8,100 hours (of which 3,920 were on type) Last 90 days - 95 hours Last 28 days - 20 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

It was intended that the aircraft would perform a ferry flight to return to Sweden. During engine start, the crew detected an electrical smell in the cabin. The co-pilot left the cockpit to try to locate the source of the odour and returned shortly after, to report that there was smoke coming from below the floor aft of the main wing spar. The smoke had increased and was now starting to impair visibility so the commander declared an emergency and ordered an evacuation. The fire services attended promptly and, using infra-red equipment, detected a heat source below the floor where the smoke had been observed. A technician later identified the source as the electrical flap motor.

The flaps had overtravelled such that they were hard against their mechanical UP stop and it was evident that the motor had overheated until the circuit breaker eventually tripped. The motor, limit switch and flap control relay were all changed and the system re-rigged but the repairer does not know which of these may have been responsible for the overtravel condition.

ACCIDENT

Aircraft Type and Registration:	Cessna 152, G-GFID
No & Type of Engines:	1 Lycoming O-235-L2C piston engine
Year of Manufacture:	1979 (Serial no: 152-82649)
Date & Time (UTC):	13 November 2014 at 1041 hrs
Location:	Near Defford, Worcestershire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Right wingtip and propeller damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	40 years
Commander's Flying Experience:	226 hours (of which 191 were on type) Last 90 days - 9 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

After a short flight from Coventry to the airstrip at Croft Farm, the pilot landed on Runway 28 but touched down just before the halfway point of the 570 m long grass strip. He reported that the grass was wet, which significantly reduced the effectiveness of the aircraft's brakes, such that he was unable to stop in the remaining distance available. In order to avoid hitting the trees and ditch located at the end of the runway, the pilot steered the aircraft to the left into an adjacent field damaging the wingtip and the propeller in the process.

ACCIDENT

Aircraft Type and Registration:	Cessna 172M Skyhawk, G-BIHI
No & Type of Engines:	1 Lycoming O-320-E2D piston engine
Year of Manufacture:	1976 (Serial no: 172-66854)
Date & Time (UTC):	18 September 2014 at 1400 hrs
Location:	Fenland Airfield, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damaged nose landing gear and propeller
Commander's Licence:	Private Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	160 hours (of which 6 were on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The pilot encountered worsening weather after takeoff and decided to curtail her flight. She joined the visual circuit in reducing visibility and flew a closer than normal approach which, combined with a light headwind on final, placed the aircraft higher on the approach than was usual. The pilot considered that a safe landing could still be achieved so continued the approach. The aircraft bounced on touchdown and the nose landing gear subsequently struck the ground prematurely and collapsed.

History of the flight

The pilot was conducting a local flight from Fenland Airfield which was expected to last about one hour. When the aircraft departed, there was a surface wind of 10 kt from 310°, approximately 5,000 m visibility with some haze, and FEW clouds at about 2,000 ft. As the aircraft flew north, the pilot encountered a lowering cloud base and worsening visibility, so decided to return to Fenland.

Runway 36 was in use, a grass runway 600 m in length. The pilot flew a downwind join but, because of the reducing visibility, flew a circuit pattern closer to the airfield than normal. This, combined with only a light headwind on final, placed the aircraft high on the final approach. Although the pilot was reluctant to execute a go-around in the deteriorating visibility, she prepared to do so.

The pilot then re-assessed the situation, believing that a safe landing could be achieved within the runway length, so continued the approach. She flared the aircraft for landing about one third of the way along the runway. The aircraft bounced and the nose landing gear subsequently struck the ground and collapsed. The pilot attributed the bounced landing to an error of judgement at the point of flare.

Comment

The worsening weather placed the pilot under pressure to make a safe landing without undue delay. Departing from the normal or familiar visual circuit pattern may have reduced her capacity to identify and deal with additional factors, such as the light headwind and high approach.

The AAIB has reported previously on 'precautionary' landings that have resulted in high and fast approaches, leading to a landing accident which is otherwise unrelated to the original problem.

ACCIDENT

Aircraft Type and Registration:	Cirrus SR20, G-VGAG	
No & Type of Engines:	1 Teledyne Continental IO-360-ES piston engine	
Year of Manufacture:	2005 (Serial no: 1572)	
Date & Time (UTC):	12 November 2014 at 1038 hrs	
Location:	London Southend Airport	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to the left wing, propeller, nose landing gear and right main landing gear	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	68 years	
Commander's Flying Experience:	2,344 hours (of which 796 were on type) Last 90 days - 19 hours Last 28 days - 3 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and photographs of the scene supplied by the airport authority	

The pilot reported that the aircraft was being landed on asphalt Runway 24 when the accident occurred. The weather was fine, with a surface wind from 190° at 14 kt, and the runway surface was damp. The aircraft bounced after a firm touchdown and the pilot applied full power with the intention of flying a go-around. However, the aircraft rolled to the left and its wing struck the runway. The aircraft deviated to the left and landed on the grass beyond the runway edge. It continued across taxiway 'B' before coming to a rest on the grass beyond, 380 m from the runway threshold. Neither occupant was injured but the aircraft sustained damage to its left wing, landing gear and propeller. The surface of the taxiway was also damaged, principally through propeller strikes and failing landing gear components.

ACCIDENT

Aircraft Type and Registration:	DHC-1 Chipmunk 22, G-BXHF
No & Type of Engines:	1 De Havilland Gipsy Major 10 MK.2 piston engine
Year of Manufacture:	1953 (Serial no: C1/0808)
Date & Time (UTC):	12 July 2014 at 1147 hrs
Location:	Goodwood Aerodrome, West Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller and right wing near wing root
Commander's Licence:	Private Pilot's Licence
Commander's Age:	65 years
Commander's Flying Experience:	671 hours (of which 119 were on type) Last 90 days - 7 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft had arrived at Goodwood for the 'Chip Fest' event. The pilot was manoeuvring the aircraft to park at the designated temporary parking area when the aircraft struck a permanent wooden fence. The aircraft was pointing approximately in-line with the direction of the fence which probably made the fence less obvious to the pilot. The aerodrome manager is currently reviewing the markings for obstacles for fly-in events.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-140 Cherokee, G-COLH
No & Type of Engines:	1 Lycoming O-320-E2A piston engine
Year of Manufacture:	1967 (Serial no: 28-23143)
Date & Time (UTC):	30 October 2014 at 1345 hrs
Location:	Full Sutton Airfield, Yorkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - 1 (Serious)
Nature of Damage:	Significant damage to upper fuselage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	19 years
Commander's Flying Experience:	121 hours (of which 2 were on type) Last 90 days - 12 hours Last 28 days - 12 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, Pilot's Operating Manual information, and published guidance on light aircraft performance matters

Synopsis

The aircraft experienced a multiple bird strike on final approach. The pilot continued to a landing but the aircraft landed long and there was insufficient runway remaining in which to stop. The aircraft overran onto unprepared ground and overturned. The occupants vacated the aircraft, with one passenger suffering a serious injury.

History of the flight

The pilot reported that the accident occurred at the end of a flight from Wellesbourne Mountford Airfield, near Stratford-upon-Avon, to Full Sutton Airfield near York. As the aircraft approached Full Sutton, the pilot assessed the surface wind as blowing directly across the single grass runway (04/22), so elected to land on Runway 04. The visibility was good, but there had been recent rain and the grass surface was described as soft and wet. The final approach was flown with full flap (40°) and at an approach speed of about 75 kt. Aircraft mass for the approach would have been about 872 kg, about 10% below the maximum permitted.

Late on the final approach, the pilot noticed a flock of birds on the runway. She thought they would disperse as the aircraft got nearer but, as the aircraft descended though about 100 to 150 ft, the birds rose from the runway and into the aircraft's path. The aircraft struck at least two birds; one hit the left wing, and one hit the propeller which left bird remains on the windscreen on the passenger's side. Being concerned for the safety of the aircraft, the pilot continued the approach. The aircraft landed some distance along Runway 04, immediately beyond the point where a hard taxiway crossed the grass runway.

The aircraft landed on all three wheels together and the pilot applied wheel brakes, but the aircraft appeared to skid on the wet grass and did not decelerate. It overran the runway onto the adjacent field, where it encountered uneven ground and overturned. The pilot and her two passengers evacuated the aircraft through the left cockpit window. It was subsequently established that one of the passengers had suffered a hairline fracture of an arm.

The pilot believed that the encounter with the birds had led to her landing further along the runway than intended. This, combined with the lack of braking action on the wet grass, had led to the overrun. The surface wind at Leeds Bradford Airport (29 nm to the west) at the time of the accident was 8 kt from 210°, so it was possible that a small tailwind component was present for landing.

Airfield information

Full Sutton Airfield has a single grass runway, designated 04/22. The published length and landing distance available on Runway 04 is 772 m. A hard taxiway (formerly a runway) crosses Runway 04 about 420 m from the start of the runway. About 330 m of runway is available for landing beyond the hard taxiway.

Light aircraft landing performance

The manufacturer's Pilot's Operating Manual for the PA28-140 gives take off and landing performance data, based on a standard aircraft at maximum mass (975 kg). The data assumes a landing on a level paved runway, in zero wind, with 40° flaps, using an approach speed of 62 kt and touching down on the main wheels at between 48 and 56 kt. The landing distance required from 50 ft in this case is 330 m.

Guidance for pilots of light aircraft in respect of takeoff and landing performance is published by the CAA in its *Safety Sense Leaflet 7c: Aeroplane Performance*, and also in the UK Aeronautical Information Circular (AIC) 127/2006. Information in these two documents highlights the fact that the manufacturer's performance figures are those achieved by a highly experienced pilot in ideal conditions using a new aircraft. The figures should be factored to take account of the actual conditions (factors being multiplied together), and it is strongly recommended that an additional safety factor (mandatory for commercial operations) is applied when deciding on the suitability of a particular runway for landing. The main conditions and performance factors pertinent to this case are shown at Table 1.

Condition	Increase in landing distance from 50 ft	Factor
A 10% decrease in aircraft mass	-10%	0.9
Wet grass up to 20 cm length (firm soil)	35%	1.35
Very short wet grass (firm soil)	60%	1.6
Tailwind component 10% of landing speed	20%	1.2
Soft ground	25% or more	1.25+
Additional safety factor		1.43

Table 1

Landing distance conditions and correction factors

Based on the aircraft details supplied by the pilot and using a tailwind of up to 5 kt, the expected landing distance from 50 ft would have been between 600 m and 710 m (depending on which factor is used for the wet grass), before any allowance is made for an increased approach speed or additional safety factor is added.

Discussion

The relatively inexperienced pilot was faced with a critical situation just before landing and had to decide quickly between continuing to a landing some way up the runway or to go-around and make a further approach with the full landing distance available. Uncertainty over the aircraft's condition and the probable shock factor of an unexpected and unpleasant event would have been factors in the pilot's decision to continue the approach. The pilot did not intend to land long but it was a consequence of her decision.

Pilots require a good understanding of the factors influencing landing performance, as well as an appreciation of how these factors can combine to produce unexpectedly long landing distances, even in normal operation. By applying this knowledge to the runway in use on the day, a pilot should be able to determine an acceptable touchdown area, beyond which there is an increasing risk of overrunning the runway.

The value of having this knowledge can be seen in situations such as that reported on here, whereby an emergency situation develops quickly, leaving the pilot very little time to decide on the safest course of action.

ACCIDENT

Aircraft Type and Registration:	Reims Cessna F172P Skyhawk, G-BITM
No & Type of Engines:	1 Lycoming O-320-D2J piston engine
Year of Manufacture:	1980 (Serial no: 2046)
Date & Time (UTC):	27 September 2014 at 1330 hrs
Location:	Near Warrington, Cheshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - 1 (Serious)
Nature of Damage:	Aircraft destroyed, local fuel contamination of soil
Commander's Licence:	Light Aircraft Pilot's Licence
Commander's Age:	76 years
Commander's Flying Experience:	1,463 hours (of which 1,432 were on type) Last 90 days - 14 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft suffered a sudden and significant loss of engine power during the cruise portion of the flight. The pilot identified a field for a forced landing, but the aircraft struck trees at its near boundary and stalled, dropping into the field of intended landing. The pilot thought the most likely cause of the power loss was a restriction in the fuel supply to the engine.

History of the flight

The aircraft was flying between Leicester Airport and Manchester Barton Aerodrome when the accident occurred. The weather conditions were fine, with no cloud, good visibility and a light north-westerly wind. The aircraft was flying at 1,200 ft altitude, its route taking it through a low level airspace corridor between Manchester and Liverpool which had a maximum permissible altitude of 1,300 ft. Without warning, there was a sudden loss of engine power. The pilot confirmed that the fuel mixture control was at fully rich and applied full carburettor heat, although he noted that the carburettor air temperature gauge was reading outside of the yellow caution range. The application of carburettor heat had no noticeable effect.

Unable to maintain altitude, the pilot made a MAYDAY call to Manchester ATC. He noticed that a small reduction in throttle setting produced smoother running, although there was no noticeable recovery in power. The pilot identified a field to the right of his track in which to make a forced landing. It was level and of suitable size, although it had trees running across the near boundary. The pilot flew an approach to the field which would take the aircraft over a section of the tree line where the trees were lower.

As the aircraft neared the field, the pilot began to suspect that it would not clear the trees, so he returned the carburettor heat to cold and applied full throttle in order to go-around. The engine did not respond, and a wingtip struck the taller trees to one side. The aircraft lost speed rapidly and stalled, descending 15 to 20 ft to the ground while carrying a small amount of forward motion. The aircraft came to rest on its left side; the passenger's door had opened during the accident sequence, allowing the passenger to escape through it. The pilot, who initially had some difficulty releasing his harness, escaped through a gap which may have been between his door and the windscreen aperture or the windscreen aperture itself.

Emergency services were quickly on scene and both occupants were taken to Warrington General Hospital. The pilot's injuries were found to be minor, but his passenger suffered a complex knee fracture.

The pilot believed that the loss of power had been caused by a restriction in the fuel supply to the engine. He recognised that carburettor icing was a possibility but thought this less likely for a number of reasons: the aircraft had not exhibited signs of an icing problem in his 14 years of flying it; carburettor icing he experienced in a Cessna 182 gave very different indications; and the carburettor temperature gauge showed a reading outside the caution range. The pilot also noted that his passenger later reported hearing an unusual noise coincident with the loss of power, although the pilot himself did not hear it.

BULLETIN ADDENDUM

The following addendum was published online on 12 February 2015 and will appear in the March 2015 Bulletin.

The aircraft suffered a sudden and significant loss of engine power during the cruise portion of the flight. The pilot identified a field for a forced landing, but the aircraft struck trees at its near boundary and stalled, dropping into the field of intended landing.

An engineering inspection of the engine revealed that the number 3 cylinder rocker cover had been punctured from the inside outwards by the inlet valve rocker arm. From the lack of impact deformations on the rocker cover, it was concluded that the damage occurred before the final accident sequence.

When the engine core was disassembled, it was found that the number 3 cylinder inlet valve had dropped into the cylinder. On removing the induction system, a piece of broken valve head was found within the tube that led to the number 1 cylinder induction valve, partially blocking the tube. This piece of material had been forced out through the broken number 3 inlet valve prior to being drawn into the number 1 cylinder inlet tube. The removal of the number 3 cylinder revealed severe damage to the top of the piston, along with severe damage to the inlet valve.

Detailed inspection of the number 3 cylinder and the dropped valve confirmed that the upper valve spring retainer had fractured in half, causing the valve to drop into the cylinder and contact the piston. This caused the valve head to fracture into three large pieces. One of the pieces stayed attached to the valve stem, the second became jammed within the valve seat in the cylinder head, and the third was found within the induction tube of the number 1 cylinder. Other smaller pieces were observed to have been liberated from the valve, some of which were most likely to have been drawn into the number 2 cylinder, causing damage to the piston before being ejected through the exhaust system.

The loss of engine power was thus attributed to the failure of the upper spring retainer of the number 3 cylinder inlet valve, which led to the valve dropping into the cylinder. With one cylinder compromised, there would have been a significant loss of power which, along with partial blocking of the number 1 cylinder induction system and minor impact damage to the number 2 piston, would have meant that there was insufficient power for sustained flight.

ACCIDENT

Aircraft Type and Registration:	Robin DR400/180 Regent, G-ETIV
No & Type of Engines:	1 Lycoming O-360-A3A piston engine
Year of Manufacture:	2000 (Serial no: 2454)
Date & Time (UTC):	2 September 2014 at 1203 hrs
Location:	Spilstead Farm Airstrip, East Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose landing gear collapsed, propeller and cowling damaged, minor damage to the left flap
Commander's Licence:	Private Pilot's Licence
Commander's Age:	73 years
Commander's Flying Experience:	698 hours (of which all were on type) Last 90 days - 29 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Spilstead Farm Airstrip is a private grass airfield with a single runway of about 700 m in length, orientated 15/33. Due to the runway slope, arrivals are typically from the south. The pilot had landed at Spilstead Farm once before, without incident, and had noted that the northern end of the runway was undulating. So, on this flight he intended to touch down near the southern threshold. The weather was good and he selected an aiming point and speed to achieve this but misidentified the threshold. The aircraft touched down approximately 25 m short of the runway, encountered soft ground and the nose landing gear collapsed. The aircraft sustained damage but the pilot was unhurt and vacated it after shutting down.

Spilstead is a private farmstrip and there is no requirement to mark the runway. The accident pilot reported that, on arrival, it was apparent that the surrounding crop had been cut for hay. This led to him mistaking a line in the cut hay for the start of the runway.

CAA Safety Sense Leaflet 12, *Strip Flying,* provides a range of advice for operating from private strips, including assessing the strip.

Miscellaneous

This section contains Addenda, Corrections and a list of the ten most recent Aircraft Accident ('Formal') Reports published by the AAIB.

The complete reports can be downloaded from the AAIB website (www.aaib.gov.uk).

BULLETIN ADDENDUM

Aircraft Type and Registration:	Airbus A330-243, G-OMYT
Date & Time (UTC):	24 June 2013 at 1110 hrs
Location:	Manchester Airport
Information Source:	Engine manufacturer's forensic report

AAIB Bulletin No 12/2013, page 18 refers

The failure of the HP turbine blade in this incident was caused by high cycle fatigue propagation due to surface damage as a result of Type 2 Sulphidation corrosion. During examination of the remains of the blade, to determine the cause of its failure, unidentified deposits were found on its surfaces. There was concern that these deposits may have been volcanic in origin, in particular from the 2010 eruption of Eyjafjallajökull in Iceland, so additional forensic analysis was carried out. That work was completed in August 2014 and did not identify compounds typically associated with volcanic activity. However, although an encounter with volcanic gaseous sulphur cannot be discounted it is concluded that the deposits probably are an accumulation of atmospheric dirt and pollutants.

BULLETIN ADDENDUM

Aircraft Type and Registration:	Short SC7 Skyvan 3, G-BEOL
Date & Time (UTC):	3 May 2013 at 1320 hrs
Location:	Weston-on-the-Green, Oxfordshire
Information Source:	Manufacturer's technical investigation report

AAIB Bulletin No 11/2013, page 14 refers

The manufacturer has completed the forensic investigation on the nose landing gear (NLG) components that detached on landing due to a fracture of the sliding tube of the oleo. The sliding tube is hollow and has an internal screw thread at its lower end to attach the nose wheel fork assembly. The fracture was near the top of the thread around its undercut[1]. The most likely mechanism leading to failure was the propagation of a fatigue crack from a machining feature in the thread undercut surface. The feature may have resulted from the dimension and tolerance of the undercut diameter on the manufacturing drawing; this meant that there was potential for the thread cutting tool to leave a mark on its surface. However, there were also cracks in some of the thread roots and a fatigue crack initiating from these features cannot be discounted.

Safety action

The manufacturer has issued a Service Bulletin (SB) 32-17M that defines a one-off visual and NDT inspection for all Short Skyvan NLG sliding tubes installed on aircraft and held as spares. These inspections are mandated by an EASA Airworthiness Directive 2014-0246 effective from 26 November 2014.

At this stage no further corrective actions resulting from this investigation are proposed. However, the manufacturer will monitor the responses to SB 32-17M and if necessary take action to maintain the continued airworthiness of the fleet.

Footnote

[1] An undercut is a recessed surface, also known as a neck, to provide clearance for the thread cutting tool on a shaft or tube. Undercut surfaces should be of a smooth finish and ideally radiused to reduce the risk of stress raising features. In this case the undercut is required because the bore decreases in diameter where the thread finishes.

BULLETIN CORRECTION

Aircraft Type and Registration:	Sikorsky S-76C, G-WIWI
Date & Time (UTC):	3 May 2012 at 2155 hrs
Location:	Peasmarsh, East Sussex
Information Source:	AAIB Field Investigation

AAIB Bulletin No 12/2014, page 23 refers

In this report it was incorrectly stated that the accident to G-REDU on 18 February 2009 was fatal. It was not.

The sentence at the top of page 23 should read:

> The AAIB report on the accident to Eurocopter EC225 LP Super Puma helicopter, G-REDU, near the Eastern Trough Area Project (ETAP) in the North Sea on 18 February 2009, was published on 17 September 2011.

The online version of this report was amended prior to publication on 11 December 2014.

TEN MOST RECENTLY PUBLISHED FORMAL REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

4/2010 Boeing 777-236, G-VIIR
at Robert L Bradshaw Int Airport
St Kitts, West Indies
on 26 September 2009.

Published September 2010.

5/2010 Grob G115E (Tutor), G-BYXR
and Standard Cirrus Glider, G-CKHT
Drayton, Oxfordshire
on 14 June 2009.

Published September 2010.

6/2010 Grob G115E Tutor, G-BYUT
and Grob G115E Tutor, G-BYVN
near Porthcawl, South Wales
on 11 February 2009.

Published November 2010.

7/2010 Aerospatiale (Eurocopter) AS 332L
Super Puma, G-PUMI
at Aberdeen Airport, Scotland
on 13 October 2006.

Published November 2010.

8/2010 Cessna 402C, G-EYES and
Rand KR-2, G-BOLZ
near Coventry Airport
on 17 August 2008.

Published December 2010.

1/2011 Eurocopter EC225 LP Super
Puma, G-REDU
near the Eastern Trough Area
Project Central Production Facility
Platform in the North Sea
on 18 February 2009.

Published September 2011.

2/2011 Aerospatiale (Eurocopter) AS332 L2
Super Puma, G-REDL
11 nm NE of Peterhead, Scotland
on 1 April 2009.

Published November 2011.

1/2014 Airbus A330-343, G-VSXY
at London Gatwick Airport
on 16 April 2012.

Published February 2014.

2/2014 Eurocopter EC225 LP Super Puma
G-REDW, 34 nm east of Aberdeen,
Scotland on 10 May 2012
and
G-CHCN, 32 nm southwest of
Sumburgh, Shetland Islands
on 22 October 2012

Published June 2014.

3/2014 Agusta A109E, G-CRST
Near Vauxhall Bridge,
Central London
on 16 January 2013.

Published September 2014.

Unabridged versions of all AAIB Formal Reports, published back to and including 1971, are available in full on the AAIB Website

http://www.aaib.gov.uk

GLOSSARY OF ABBREVIATIONS

aal	above airfield level
ACAS	Airborne Collision Avoidance System
ACARS	Automatic Communications And Reporting System
ADF	Automatic Direction Finding equipment
AFIS(O)	Aerodrome Flight Information Service (Officer)
agl	above ground level
AIC	Aeronautical Information Circular
amsl	above mean sea level
AOM	Aerodrome Operating Minima
APU	Auxiliary Power Unit
ASI	airspeed indicator
ATC(C)(O)	Air Traffic Control (Centre)(Officer)
ATIS	Automatic Terminal Information System
ATPL	Airline Transport Pilot's Licence
BMAA	British Microlight Aircraft Association
BGA	British Gliding Association
BBAC	British Balloon and Airship Club
BHPA	British Hang Gliding & Paragliding Association
CAA	Civil Aviation Authority
CAVOK	Ceiling And Visibility OK (for VFR flight)
CAS	calibrated airspeed
cc	cubic centimetres
CG	Centre of Gravity
cm	centimetre(s)
CPL	Commercial Pilot's Licence
°C,F,M,T	Celsius, Fahrenheit, magnetic, true
CVR	Cockpit Voice Recorder
DFDR	Digital Flight Data Recorder
DME	Distance Measuring Equipment
EAS	equivalent airspeed
EASA	European Aviation Safety Agency
ECAM	Electronic Centralised Aircraft Monitoring
EGPWS	Enhanced GPWS
EGT	Exhaust Gas Temperature
EICAS	Engine Indication and Crew Alerting System
EPR	Engine Pressure Ratio
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
FAA	Federal Aviation Administration (USA)
FIR	Flight Information Region
FL	Flight Level
ft	feet
ft/min	feet per minute
g	acceleration due to Earth's gravity
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
hrs	hours (clock time as in 1200 hrs)
HP	high pressure
hPa	hectopascal (equivalent unit to mb)
IAS	indicated airspeed
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IP	Intermediate Pressure
IR	Instrument Rating
ISA	International Standard Atmosphere
kg	kilogram(s)
KCAS	knots calibrated airspeed
KIAS	knots indicated airspeed
KTAS	knots true airspeed
km	kilometre(s)
kt	knot(s)
lb	pound(s)
LP	low pressure
LAA	Light Aircraft Association
LDA	Landing Distance Available
LPC	Licence Proficiency Check
m	metre(s)
mb	millibar(s)
MDA	Minimum Descent Altitude
METAR	a timed aerodrome meteorological report
min	minutes
mm	millimetre(s)
mph	miles per hour
MTWA	Maximum Total Weight Authorised
N	Newtons
N_R	Main rotor rotation speed (rotorcraft)
N_g	Gas generator rotation speed (rotorcraft)
N_1	engine fan or LP compressor speed
NDB	Non-Directional radio Beacon
nm	nautical mile(s)
NOTAM	Notice to Airmen
OAT	Outside Air Temperature
OPC	Operator Proficiency Check
PAPI	Precision Approach Path Indicator
PF	Pilot Flying
PIC	Pilot in Command
PNF	Pilot Not Flying
POH	Pilot's Operating Handbook
PPL	Private Pilot's Licence
psi	pounds per square inch
QFE	altimeter pressure setting to indicate height above aerodrome
QNH	altimeter pressure setting to indicate elevation amsl
RA	Resolution Advisory
RFFS	Rescue and Fire Fighting Service
rpm	revolutions per minute
RTF	radiotelephony
RVR	Runway Visual Range
SAR	Search and Rescue
SB	Service Bulletin
SSR	Secondary Surveillance Radar
TA	Traffic Advisory
TAF	Terminal Aerodrome Forecast
TAS	true airspeed
TAWS	Terrain Awareness and Warning System
TCAS	Traffic Collision Avoidance System
TGT	Turbine Gas Temperature
TODA	Takeoff Distance Available
UHF	Ultra High Frequency
USG	US gallons
UTC	Co-ordinated Universal Time (GMT)
V	Volt(s)
V_1	Takeoff decision speed
V_2	Takeoff safety speed
V_R	Rotation speed
V_{REF}	Reference airspeed (approach)
V_{NE}	Never Exceed airspeed
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional radio Range

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