ACCIDENT

Aircraft Type and Registration:	Beech 95-B55 Baron, G-RICK	
No & Type of Engines:	2 Continental Motors Corp IO-470-L piston engines	
Year of Manufacture:	1972 (Serial no: TC-1472)	
Date & Time (UTC):	3 May 2015 at 1113 hrs	
Location:	West of Abernyte, near Dundee, Scotland	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Fatal)	Passengers - 1 (Fatal)
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	37 years	
Commander's Flying Experience:	3,900 hours (of which 100 were on type) Last 90 days - 60 hours Last 28 days - 33 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft was cleared for an ILS/DME approach to Runway 09 at Dundee Airport. Although it was raining and windy, the weather conditions were suitable for the approach. The pilot made a radio transmission reporting he was 4 nm to the west of the runway, on final approach, but the aircraft failed to arrive. A Search and Rescue helicopter located the aircraft wreckage on high ground 6.7 nm west of the airport. The investigation determined that it was likely that the instrument approach, carried out in IMC, was flown using range information based on the GPS distance from the 'DND' NDB, located 2.6 nm west of the airport, instead of using DME distance from the runway.

History of the flight

Shortly after 1015 hrs on Sunday 3 May 2015, the pilot of G-RICK telephoned ATC at Inverness to 'book out to Dundee'. He passed the following details: two people on board; the flight would take 30 minutes; three hours fuel endurance, and he planned to route direct, VFR at FL70. The pilot stated that he would be requesting a Basic Service[1] and when asked about the time of his return, he explained that the aircraft would not be returning to Inverness for a couple of weeks. The purpose of the flight was to position the aircraft to Dundee for its annual inspection.

Footnote

[1] Air Traffic providers in the UK offer different levels of Air Traffic Service: Basic, Traffic, Deconfliction and Procedural. These are described in the UK CAA Publication CAP 774.

The pilot was familiar with G-RICK and had flown it many times before, including flying it into Dundee. He asked the owner if he would like to join him on the flight, but the owner had a previous engagement, so a friend joined him instead. The friend held a PPL, but was not qualified to fly G-RICK.

At 1030 hrs, G-RICK took off from Inverness and climbed to FL70. The pilot initially requested a Basic Service, but soon asked for this to be upgraded to a Traffic Service. At 1059 hrs he called Dundee ATC to report that they were 16 nm to the north of Dundee, at FL50, and requested an ILS approach to Runway 09. They were given a Procedural Service, asked to route to the 'DND[2]' NDB, and were cleared to descend to 3,000 ft. At 1105 hrs, G-RICK was cleared for the ILS/DME 09 and asked to call beacon outbound, which was acknowledged. G-RICK's next call of "LOCALISER ESTABLISHED", was made at 1110 hrs. The pilot then called "FOUR MILES" and shortly afterwards, at 11:12.55 hrs, the pilot of G-RICK read back his clearance to land.

Late that morning, a CAA examiner at Perth Airport, approximately 11 nm west of Dundee Airport, heard a light twin aircraft fly quite low overhead. He could not see anything as the cloud base was too low, but he noted it was unusual, as IFR traffic did not normally transit low through the Perth Airport overhead.

Another earwitness, a flying instructor, recalled that around midday (1100 hrs UTC) he was inside his house, approximately 5.2 nm from the 'DND', when he heard a twin-engine piston aircraft at quite a high power setting, flying close by. He commented that the engines sounded loud, but they seemed to be operating normally. He did not see the aircraft because of low cloud, but heard it clearly, even though his house was fitted with double glazed windows. He thought it very unusual, as aircraft did not normally fly so low in that area.

The ATC controller at Dundee waited for G-RICK to appear, and was concerned when, after a few minutes, it was still not in sight and did not respond to radio calls. The weather conditions were suitable for the ILS approach and previous aircraft had not reported any problems during the approach to land. At 1117 hrs the controller asked RAF Leuchars and then Scottish Radar if they knew the whereabouts of G-RICK. When both reported they had no contact with the aircraft, he initiated overdue action.

At approximately 1145 hrs, the Managing Director (MD) of the maintenance company was called at home and informed that ATC had lost contact with G-RICK. He drove to the airport locality to see if he could assist. A SAR helicopter arrived at 1257 hrs and commenced a search, but it was initially unable to locate the aircraft. The MD, who is also a flying instructor, suggested via ATC that the SAR helicopter should conduct a search in the area 4 nm to the west of the 'DND' NDB, as students he flew with often confused DME range with the GPS distance from the NDB.

Footnote

[2] The 'DND' is the NDB facility which is the Initial Approach Fix for the ILS/DME procedure for Runway 09 at Dundee.

At 1353 hrs, the SAR helicopter located the wreckage at a position 6.7 nm west of the threshold of Runway 09, 4.0 nm to the west of the 'DND'. It landed nearby and the winch operator and winchman walked to the accident site. It quickly became evident that neither occupant had survived the accident.

Medical and pathological information

Post-mortem examinations of the pilot and passenger of G-RICK were conducted. The pathologist concluded that they had both died from multiple injuries, consistent with having been caused during the impact sequence. There were no medical or toxicological factors that may have contributed to the accident.

Recorded data

Radar and GNSS[3] data

Radar data, including altitude information, covering the majority of the accident flight was available from several of the NATS[4]-operated radar heads. A Garmin GPSMAP 696 receiver was recovered from the accident site which, although damaged, contained non-volatile memory that was successfully removed and downloaded at the AAIB. The track of the accident flight was subsequently extracted from the download. The track recording started with the aircraft taxiing at Inverness Airport, before getting airborne at 1030 hrs. It ended at 1113 hrs, at a position within 400 metres of where the aircraft wreckage was located.

Figure 1 shows the last 8 minutes of recorded ground track as G-RICK tracked south towards the 'DND' beacon, before turning right to follow the procedural pattern for the Dundee ILS/DME approach to Runway 09. The outbound leg was extended, beyond the procedure, to a distance of 11 nm from the DME. The final descent commenced when the aircraft was 6.7 nm from the 'DND' beacon (9.4 nm from the DME), on an easterly track back towards the 'DND'.

The altitude and ground profile on the approach toward Dundee are shown in Figure 2 (starting just after passing Perth Airport). Also plotted in Figure 2 is G-RICK's groundspeed, which was between 100 and 110 kt during the final descent.

Footnote

[3] Global Navigation Satellite System.
[4] NATS is the UK's national air traffic services provider.

Figure 1

Final 8 minutes of G-RICK's ground track recorded by the GPSMAP 696

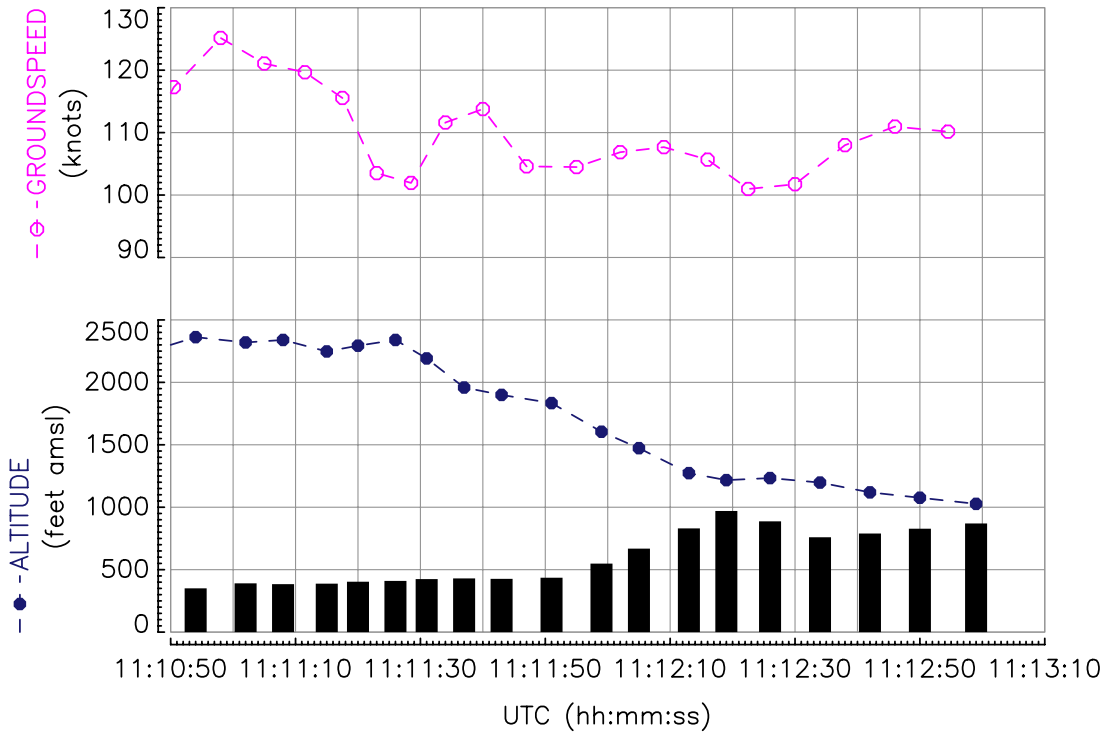

Figure 2

Altitude recorded by the GPSMAP 696 (with ground elevation indicated by black bars) and calculated groundspeed (averaged between points)

Aircraft information

The Beech Baron is a light twin-engine aircraft designed to be operated by a single pilot. G-RICK was equipped for flight in IMC. In 2009, the avionics equipment was updated by the installation of a Garmin GNS 530W into the Com/Nav 1 position, along with a new antenna and navigation indicator. A terrain database was included in the unit fitted to this aircraft.

The aircraft was also fitted with a Bendix King KNS80 in the Nav 2 positon, installed below the GNS 530W and to the right of the engine instruments. In addition to being able to display navigation and ILS information, it also included a DME receiver. The owner reported that the DME receiver was known to be intermittent, although engineers had been unable to locate a fault.

The aircraft was equipped with an autopilot, but this was unserviceable and the owner reported that the aircraft was always flown manually.

Maintenance history

The Airworthiness Review Certificate (ARC) for the aircraft was issued on 23 October 2014, with an expiry of 20 December 2015. The last scheduled maintenance, a 50 hour/6-monthly inspection, was completed on 24 October 2014 and the next maintenance, an annual inspection, was due on 18 March 2015.

The maintenance organisation had been in discussion with the aircraft owner about completing the overdue annual inspection and the possibility of the aircraft being flown to Dundee. The pilot was aware of these discussions.

As the aircraft had not flown since November 2014, the owner and the pilot of the accident flight flew the aircraft on 17 April 2015 to check for defects before the aircraft went into maintenance. The owner reported that on that flight everything had operated as expected.

In order for the aircraft to be flown with the overdue annual inspection, an application should have been made to the CAA, by the aircraft owner or the maintenance organisation, for a temporary Permit to Fly. There was no evidence that this application had been made.

Accident site

The aircraft first contacted the ground, about 900 ft amsl, on the downslope of a hill approximately 6.7 nm to the west of Dundee Airport and 0.27 nm north of the Runway 09 extended centreline. The aircraft was on a heading of approximately 098°(M), in a wings-level attitude, with the landing gear extended.

The initial contact was with soft ground covered in dense heather; a second contact on similar ground showed evidence of the rotating propellers striking the ground. The aircraft, still in a wings-level attitude, then struck trees on the edge of a lightly wooded area and became fragmented. There were several small localised fuel fires and a scorched area indicated that a brief flash fire had occurred, probably caused by the ignition of atomised fuel ejected from the ruptured fuel tanks.

Examination of the evidence at the accident site indicated that the aircraft was intact prior to the impact and the two altimeters had the correct barometric pressure set. The wreckage was then recovered by the AAIB for more detailed examination.

Wreckage examination

Although the wreckage was fragmented and parts had suffered fire damage, it was possible to determine that both engines were producing power at the time of impact. Within the limitations of the impact damage, no evidence was found of any failures that could have contributed to the accident.

Garmin GNS 530W

The GNS 530W is a widely used integrated communication, navigation (including ILS but not DME) and GPS system with a colour moving map display. (It is similar in capability to the Garmin GNS 430, but has a larger display screen.) It is multi-functional and can be used to provide information, either GPS or from a ground-based navigational aid (Nav), to a horizontal situation indicator (HSI)[5].

Figure 3
Garmin GNS 530W

The communication section (COM) on the installation (left side of the screen) is used to provide the primary VHF radio frequency selected. ILS or VOR frequencies selected are displayed beneath the radio frequency. If an ILS frequency is selected and the equipment is receiving the correct signal, the equipment displays the identification (IDENT) letters of the selected facility. This does not, however, mean the selected beacon is providing an

Footnote

[5] The HSI is an instrument normally mounted below the artificial horizon in place of a conventional direction indicator. It combines the heading indicator with a VOR/ILS/GPS deviation indicator and is one of the pilot's primary flight instruments.

output to the HSI. That functionality is determined by the Course Deviation Indicator (CDI) key which is used to toggle between the navigation sources. In G-RICK, the status of the CDI key was also indicated by HSI source annunciator lights, mounted on the instrument panel just above the pilot's main attitude indicator (Figure 4). The illuminated light indicated whether ground-based Nav 1 (VOR/ILS) or GPS was the source of the navigation data being displayed on the HSI.

Figure 4
HSI Source Annunciator Lights

The omni-bearing selector (OBS) key is used to select manual or automatic sequencing of waypoints. Pressing the OBS key selects OBS mode, which retains the current '*active to*' waypoint as the navigation reference, even after passing the waypoint (ie it prevents sequencing to the next waypoint). Pressing the OBS key again returns the unit to normal operation, with automatic sequencing of waypoints. When OBS mode is selected, the pilot may set the desired course to/from the selected waypoint using the Select OBS Course pop-up window or, more simply, by using the external OBS selector on the HSI.

The '*direct-to*' function provides a quick method of setting a course to a destination waypoint. Once a '*direct-to*' command is activated, the GNS 530W establishes a point-to-point course line from the present position to the selected '*direct-to*' destination. Navigation data on the various NAV pages provides steering guidance until the '*direct-to*' is cancelled or replaced by a new destination; GPS distance from the selected '*direct-to*' waypoint is displayed on the unit's screen.

The GNS 530W has many functions (the pilot's guide and reference consists of 288 pages), but there is no requirement for pilots to receive training on such specific navigation equipment. The GNS 530W in G-RICK was fitted with a terrain database required for the TAWS. This could have been used to enhance terrain awareness, but evidence from the owner was that this functionality was not fully understood and it was therefore unlikely to have been used on the accident flight.

The navigation and radio equipment was severely damaged by the impact forces and it was not possible to determine their settings. However, examination of the HSI source annunciator bulb filaments under a microscope showed that the GPS filament had characteristic plastic deformation, indicating that it was illuminated at the time of impact (Figure 5). This indicated that GPS-derived navigation data was being displayed on the HSI at the time of the accident.

GPS **Nav 1 (VOR)**

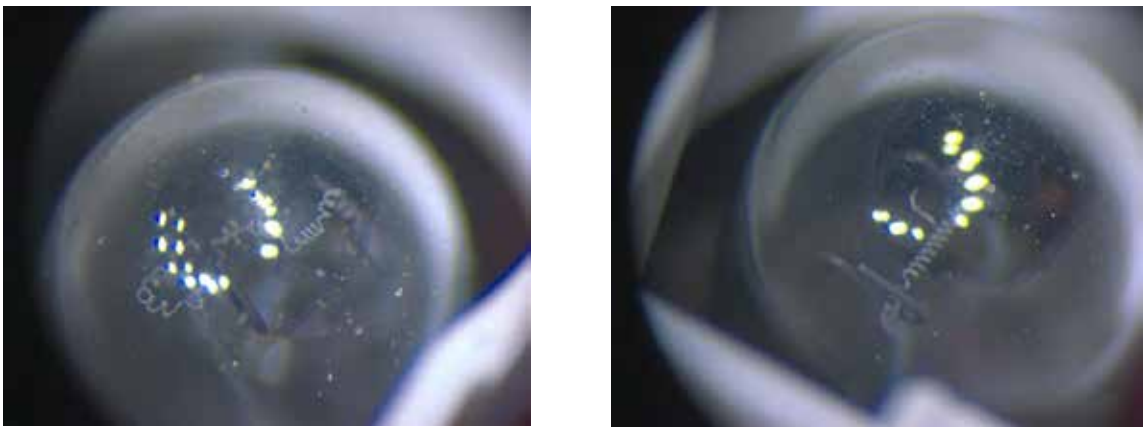

Figure 5

HSI source annunciator lightbulbs,
showing plastic deformation of the GPS bulb filament

Meteorology

Frontal cloud and associated moderate to heavy rain was affecting Eastern Scotland at the time of the accident, with moderate turbulence and mountain wave activity forecast. At Dundee there was a strong and gusty easterly wind, with rain reducing the visibility to below 5,000 m. The cloud base at Dundee Airport was 800 ft. Cloud bases on the approach to Runway 09, further inland at higher elevations, would have been significantly lower and the strong gusty wind would have generated low-level turbulence. The TAFs and METARs around the time of the accident were as follows:

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EGPN (Dundee) Forecasts

030859Z 0309/0318 09017KT 8000 -RA BKN018 TEMPO 0309/0316 10022G32KT 5000 RA BKN012
031034Z 0310/0318 09017KT 8000 -RA BKN012 TEMPO 0310/0316 10022G32kt 4000 RADZ
BKN008

Actuals

031020Z 09021KT 060V130 5000 RA BKN009 BKN018 07/06 QO997 =
031050Z 09021G31KT 4000 RA BKN008 BKN016 07/06 Q0996 =
031120Z 09022KT 5000 RA BKN009 BKN016 07/06 QO996 =
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Pilot's flying history

The pilot commenced his PPL training in South Africa in 2003, and gained his CPL in 2005. He then worked for a regional airline as a co-pilot on the Jetstream 31. He first flew G-RICK in 2005. He was awarded his ATPL in 2007 and his command on the Jetstream in 2008, and at the same time he started to fly G-RICK more regularly. In 2010, the regional airline went into receivership, and he started to fly on an ad-hoc basis for the owner of G-RICK, who had recently purchased a Beech B200GT Super King Air. In 2011 he started to work for an aircraft manufacturer, performing demonstration flights, whilst still flying G-RICK on a regular basis.

In 2014 he was employed on a part-time contract, as a first officer, by an airline operating the Boeing 737. During the winter months he was given time off from the airline and he used this time to continue to fly the King Air, and occasionally G-RICK. The pilot was familiar with Dundee, having flown there many times.

The investigation was unable to locate a valid multi-engine piston (MEP) rating for the pilot. His records showed he had a valid King Air rating and Single Pilot Instrument Rating, but the last MEP validation, recorded on his JAA licence, had expired on 31 August 2012. Since that date the pilot's logbook showed 13 flights in G-RICK prior to the accident flight.

A review of the pilot's training records held by his previous two employers revealed that he had satisfactorily completed all the required training and testing. There was nothing in his training files considered relevant to the accident.

Dundee Airport

Dundee Airport is located 0.5 nm south of Dundee City and is operated by Highlands and Islands Airports Limited (HIAL). Its Air Traffic Control Zone (ATZ) is located in Class G[6] airspace, to the north-west of the RAF Leuchars Military Air Traffic Zone (MATZ). Dundee Airport is not equipped with radar, and ATC provide a Procedural Service to aircraft conducting instrument approaches. There were no approved ATC procedures at Dundee that included the use of GPS-derived information. There is high ground approximately 6 nm to the west of the airport, rising to around 1,200 ft amsl.

Dundee ILS/DME RWY 09

The ILS/DME procedure for Runway 09 at Dundee, dated 15 March 2015, as published in the UK AIP, was approved by the CAA and was in accordance with International Civil Aviation Organisation (ICAO) Document 8168, Procedures for Air Navigation Services (PANS), Aircraft Operations (OPS), Volume II, Construction of Visual and Instrument Flight Procedures. It is coded I-DDE and transmits on frequency 110.1 MHz. The localiser is aligned with the final approach track for Runway 09, on a magnetic track of 093°. The associated glidepath signal radiates on the frequency-paired channel 334.7 MHz, at a glidepath angle of 3°. The DME, which is frequency-paired with the ILS, indicates zero nautical miles at the threshold of Runway 09.

The ILS/DME procedure begins at the Initial Approach Fix (IAF) - the 'DND' NDB. This radiates on the frequency 394.0 kHz and is located 2.6 nm from the threshold of Runway 09, 230 m north of the localiser centreline. Navigation using NDBs is less intuitive for a pilot than navigation using GPS. Anecdotal evidence suggests this may encourage some pilots to use GPS navigation, even where its use is not approved.

Footnote

[6] Uncontrolled airspace.

The UK AIP contains numerous notes concerning this approach, including:

> *'Due to terrain, LOC and Glidepath flag alarms may be experienced at northern edge of coverage when below glidepath sector'*
>
> *'procedure not available without DME I-DDE'*
>
> *'the eastern edge of the Perth ATZ lies 9.5 nm west of THR RWY 09. To prevent conflict with possible VFR traffic in the Perth ATZ pilots should not extend the outbound leg of the base turn beyond the prescribed procedural distances or timings.'*

The published procedure (Figure 6) required the aircraft to fly over the 'DND' beacon at an altitude of 3,000 ft, then turn onto an outbound track (255° for this category of aircraft) and descend to 2,200 ft amsl. At a distance of 8 nm from the DME, pilots should commence a level right turn and use ILS guidance to intercept the localiser. Pilots should continue to fly level until they intercept the glidepath. As a cross-check, the approach chart indicates that glidepath interception at 2,200 ft should occur when the aircraft is 6.7 nm from the DME. The pilot should then follow the localiser and glidepath guidance down to the decision altitude. There are additional advisory heights on the approach chart at each nautical mile from touchdown.

There is a separate, but very similar, approach chart for aircraft conducting a Localiser/DME approach. This is a non-precision approach, where lateral guidance is provided by the ILS localiser, and the chart provides a recommended profile, with target heights for specified DME distances. This approach has a higher minimum than the ILS and it is used for training, or when the ILS glidepath is not available.

The pilot of an aircraft who flew the ILS approach immediately prior to G-RICK experienced no problems with the guidance during his approach. The ILS was withdrawn from service as a precaution immediately after the accident. The following day it was flight-checked and found to be fully serviceable.

A CAA review of the approach procedures at Dundee Airport concluded that the equipment was serviceable, and that its installation, operating procedures, the Instrument Approach Procedure (IAP), and ATC procedures associated with the approach, all complied with the applicable regulations.

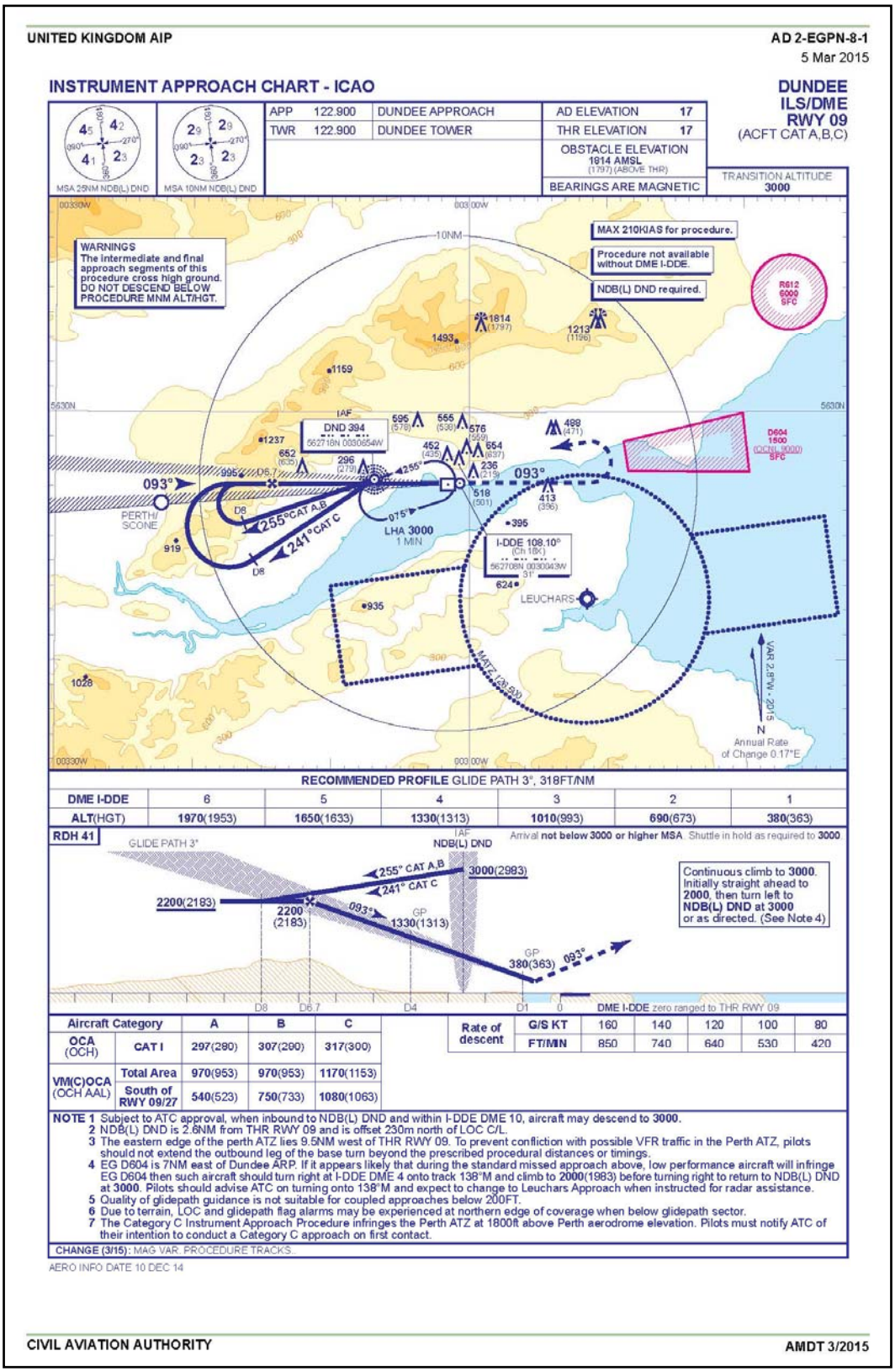

Figure 6

Dundee ILS/DME RWY 09 approach, dated 5 March 2015

Investigation flight

A test flight was conducted in a Beech Baron, fitted with a Garmin GNS 530 feeding navigational information to the HSI, as part of the investigation. Three instrument approaches were flown to Dundee Runway 09 in VFR conditions. The published procedure was flown on the first approach. On the second approach, the ILS/DME was selected on the GNS 530 and the approach was flown leaving GPS as the navigational feed to the HSI. The third approach was flown using the GPS *'direct to'* function to the 'DND'. Then, after pressing the OBS button on the GNS 530, the outbound radial from the NDB was selected using the external OBS selector on the HSI, and the aircraft was flown to 8 nm from the 'DND' rather than the DME. The inbound radial to the ILS was selected, but the CDI key was not pressed (leaving the GPS source navigating the aircraft to the 'DND'). On the first two approaches the aircraft's track was to the south of the accident site, on the third, with the HSI steer bar indicating on track, the test aircraft first flew directly over Perth Airport and then the accident site.

Previous CFIT accidents at Dundee Airport

The investigation reviewed previous CFIT accidents that had occurred on approach in IMC to the same runway at Dundee Airport.

In 1983, G-OCAL, a Partenavia P68B, collided with the ground whilst conducting the NDB approach. The pilot, who held a CPL, descended below the specified descent profile. Later that year G-AZYI, a Cessna 310Q, crashed approximately 200 m from where G-OCAL struck the ground; the pilot, the holder of a Senior CPL, was attempting to fly the NDB approach. In 1988 G-BRAD, a Beech B55 Baron crashed 7.5 nm from the threshold whilst conducting an NDB approach.

At the time of these accidents, the NDB was the only approach aid available at Dundee. The ILS DME for Runway 09 was installed in 1999 to provide a precision approach capability.

Other relevant incidents

The investigation asked several flying instructors, who flew the instrument approach at Dundee regularly, whether they were aware of any issues with the approach. Some instructors reported that it was not uncommon for pilots of GPS-equipped aircraft to mistake GPS ranges from the NDB with DME ranges from the threshold. The instructors stated that one of the key learning points taught to their students was to appreciate the difference between DME and GPS range. Another common mistake was for students to forget to select the CDI key, leaving the HSI to take its information from the GPS source rather than the intended ILS source; many flying schools discourage the mixing of procedural and GPS navigation.

In order to determine if the additional emphasis flight instructors were paying to the problem was effective, CAA examiners, using Dundee for instrument flight tests, were asked if they had observed students mistaking GPS range for DME range, or leaving the HSI in GPS mode during the ILS approach. The examiners confirmed that some students

under test were still making these mistakes. One examiner recounted an occasion when a student under test in VMC, but with instrument screens fitted, used GPS referenced distance to the 'DND' NDB rather than DME and commenced his descent 2.7 nm early. The aircraft would have come dangerously close to the ground had the examiner not terminated the test.

Bowtie risk model and hierarchy of hazard control

The 'Bowtie' is a barrier risk model used by the CAA[7], and other organisations, to assist in the identification and management of risk. The AAIB, with assistance from the CAA, created a bowtie model for this accident. The model considered the threats and the preventative controls intended to eliminate the threats entirely, or prevent them from progressing to an unsafe condition. It also considered those controls which should prevent the unsafe condition resulting in an accident.

The hierarchy of hazard control (Figure 7) is a generic system used by industry to minimize or eliminate exposure to hazards. It is a widely accepted system promoted by numerous safety organisations. The hazard controls are listed in order of decreasing effectiveness.

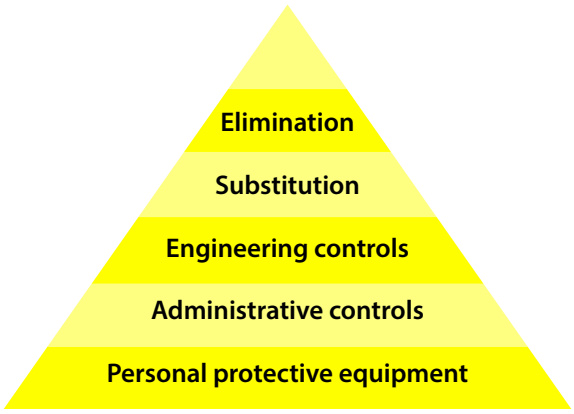

Figure 7

Hierarchy of hazard control

In the Bowtie model for this accident, the controls that failed to prevent the threat escalating into an unsafe condition were related to pilot performance, which can be mitigated by training. However, training is an 'Administrative' control in the hierarchy of hazard control and is therefore not the most effective. A more effective way of minimizing the hazard would be by 'Substitution'; for example, a redesigned instrument approach at Dundee that is more tolerant of human error.

Analysis

The pilot was cleared to fly the ILS/DME approach to Runway 09 at Dundee. The procedure specifies distances referenced from the DME. However, the radar and GPS tracks of the accident flight are consistent with the aircraft having flown a GPS-based approach

Footnote

[7] The CAA template can be viewed at their website www.caa.co.uk/Bowtie

to the 'DND' NDB. The GPS annunciator bulb confirmed that the HSI was being fed by the GPS rather than the ILS and the pilot's "FOUR MILE" R/T call, made when the aircraft was approximately 7 nm from the runway threshold, indicates that he had lost situational awareness[8].

Having navigated to the 'DND', it is probable that the pilot intentionally flew the outbound radial using the GPS feed to the HSI. The ILS frequency should have been selected on the GNS 530W prior to commencing the approach and its IDENT would have been displayed near the distance to the selected waypoint in use (the 'DND'). Evidence suggests, however, that the pilot mistook the GPS distance from the 'DND' for the distance from the DME; flying instructors and examiners indicated this was a common error.

As he carried out the base turn, the pilot is likely to have selected the ILS inbound course on the HSI but, by omitting to press the CDI key, the HSI would have continued to display GPS, rather than ILS information. This would have presented the pilot with sensible lateral guidance but, with no glideslope information, the glidepath indicator on the HSI should have displayed an '*Off*' flag. An *'Off'* flag on the glideslope would concern a pilot wishing to fly an ILS approach. It is possible, however, that the pilot in this accident believed the lack of a glidepath was connected to the warning note on the approach chart about glidepath and localiser flag alarms.

With no glideslope guidance, the pilot may have reverted to a Localiser/DME approach. This required a descent to start at 6.7 nm from the DME. However, the pilot commenced his descent at 9.4 nm from the DME; 6.7 nm from the 'DND'. This was probably the GPS distance displayed on the GNS 530W. If the pilot was flying the Localiser/DME approach profile to the 'DND'; he should have been at a height of 1,330 ft amsl at a distance of 4 nm, but the accident occurred with the aircraft at 900 ft amsl. The reason why the aircraft was so low is not clear. However, hill effect[9] and turbulent conditions may have been contributory factors.

The accident site was approximately two degrees north of the correct inbound track for the ILS. If ILS data had been selected as the source for the HSI, the steer bar, at this position, would have shown nearly full scale deflection to the right and the glideslope indication would have been full *'fly up'*. Had the pilot programmed the GNS 530W to provide guidance for the ILS approach, the aircraft would probably have followed the track of the correct procedure, as demonstrated by the test flight. With GPS data being displayed, and the GNS 530W selected to navigate '*direct to'* the 'DND', the HSI steer bar would have shown the aircraft to have been on track, albeit with no glideslope indication.

TAWS may have alerted the pilot to the proximity of terrain, had it been selected. However, the screen that would have displayed terrain information was outside the pilot's primary instrument scan and G-RICK's GNS 530W was not equipped with any audio terrain alert.

Footnote

[8] The aircraft's actual situation is not accurately reflected by the pilot's perception.
[9] Hill effect is where an increase in wind speed as air flows over a hill, causes a localised reduction in pressure.

Previous accidents at Dundee occurred when the airport was only equipped with an NDB. The ILS/DME provides for a more accurate approach to be flown, increasing the level of safety, but the procedure still commences at the offset NDB. Anecdotal evidence suggests that some pilots may choose to navigate to the ILS using the GPS instead of the NDB, as it is easier to follow. This is not an approved procedure.

This accident can be categorised as Controlled Flight into Terrain (CFIT). The CAA have identified CFIT as one of their '*Significant 7*', these being the seven top safety concerns identified by CAA safety analysis. In their report (CAA Paper 2011/03) the CAA identified loss of situational awareness as a major factor in the lead up to a CFIT accident. In this accident the pilot's use of GPS and the approach design probably contributed to his loss of situational awareness. The risk of CFIT was increased by the poor weather and the high terrain on the approach. Radar surveillance, had it been available, would have shown that G-RICK had flown 11 nm outbound from the airport, not the required 8 nm, and the inbound track flown was to the north of the correct track. This might have alerted ATC, but Dundee Airport is not equipped with radar and therefore ATC were unable to observe the aircraft deviating from the published instrument approach procedure.

Discussion

The evidence suggests the GPS was being used in its simplest ('*direct to*') mode. This probably contributed to the pilot confusing GPS distance from the 'DND' with DME distance. Modern aircraft GPS units are very capable and complex pieces of navigational equipment. Differences training is required before pilots are permitted to fly aircraft equipped with electronic flight instrument systems (EFIS), yet no formal training is required before pilots can fly with a complex GPS system such as the GNS 530W. Pilots are, however, encouraged to become familiar with the GPS equipment they operate before relying on it. CAA Safety Sense Leaflet 25: *'Use of GPS'* contains valuable information for pilots on the correct use of GPS.

Despite training and a raised awareness of the risk, even experienced airline pilots can mistake GPS information with information from ground-based navigational aids. Pilots flying an approach in VMC and inadvertently navigating to the wrong position using GPS however, will have sight of the ground before reaching their minima and will be able to recover the situation without endangering the aircraft. Many of these situations probably go unreported and it is likely, therefore, that while GPS-equipped aircraft continue to fly procedures involving offset beacons, errors of this kind will continue.

The CAA commented: '*the procedures are designed to be flown in a prescribed manner that all IR pilots will be trained for and competent in; going outside SOPs* (Standard Operating Procedures) *is a factor not related to the design or procedure itself and something that we cannot mitigate'.* However, if an approach were designed to start at the airfield, either using an airfield-based beacon or a GPS-defined position (an RNAV waypoint), the risk of a pilot commencing a descent in the wrong place would be significantly reduced. Until recently, the design criteria for instrument approaches did not allow the CAA to grant approval for approach procedures to ground-based navigational aids that commenced at an RNAV waypoint. However, the ICAO design criteria have been amended and the new design criteria, which will allow such approvals, become effective from November 2016.

Safety actions

Dundee Airport has high ground on the approach, an offset NDB and no radar surveillance. This combination can result in a pilot inadvertently letting down to the NDB instead of the runway in IMC conditions, with no effective 'safety net'. Aviation should however, in so far as possible, be an 'error tolerant' environment.

As a result of this accident HIAL have implemented a number of immediate safety actions, including amending the ATIS broadcast to include the statement: 'Pilots are reminded that the NDB and DME are not co-located'.

HIAL have also commissioned a safety survey, to be conducted by a Joint Working Group, with representatives invited from NATS, the CAA and relevant aircraft operators. The survey will investigate the hazards and potential risks associated with the Dundee instrument approach procedures and the remotely located NDB. Its scope is intended to be broad, but will consider the feasibility of:

- relocating the remote NDB to within the airport grounds;
- installing Air Traffic Monitoring in the Visual Control Room;
- amending the notes section of the Dundee instrument approach charts in the UK-AIP;
- installing power amplifiers to 'balance' the output signal from the Glide Path, in order to remove the warning about localiser and glidepath flag alarms on the instrument approach plate;
- reviewing the Dundee's RNAV procedure designs, which were submitted to the CAA for approval in June 2014, with a view to establishing RNAV approaches within a reasonable timescale;
- using Automatic Dependant Surveillance Broadcasting (ADS-B[10]) as an ATC situational awareness tool, as well as other administrative and training mitigations.

The final report of the safety survey, including recommendations made, is expected to be available by the end of January 2016.

Conclusion

The aircraft collided with high ground 6.7 nm to the west of Dundee Airport whilst conducting an instrument approach to Runway 09 in IMC. Evidence indicates that the pilot probably mistook the distances on his GPS, which were from the NDB, as DME distances from the threshold of Runway 09, and therefore commenced his descent too early. Anecdotal evidence suggests that mistaking GPS distance from the 'DND' NDB with DME distance is a common error made by pilots. The operator of Dundee Airport is taking safety actions, intended to prevent a recurrence.

Footnote

[10] ADS–B is a cooperative surveillance technology in which an aircraft determines its position via satellite navigation and periodically broadcasts it, enabling it to be tracked.