ACCIDENT

Aircraft Type and Registration:	Cessna F150L, G-BABB
No & Type of Engines:	1 Teledyne Continental O-200-A piston engine
Year of Manufacture:	1972
Date & Time (UTC):	19 July 2006 at 1530 hrs
Location:	Eastwood Park, Southend on Sea, Essex
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Student pilot
Commander's Age:	16 years
Commander's Flying Experience:	15 hours (all of which were on type) Last 90 days - 7 hours Last 28 days - 4 hours
Information Source:	AAIB Field Investigation

Synopsis

The student, who was training at Southend Airport towards the issue of a Private Pilot's Licence, was on his second solo flight. Having established the aircraft on final approach, the student was instructed to go around so that a faster aircraft approaching to land behind his aircraft would not catch up with it. Both the controller's instruction and the student pilot's acknowledgement involved non-standard RTF phrases. In order to avoid any possibility of conflict between the two aircraft the student was then instructed to turn away from the final approach track. During this manoeuvre, the student flew level at low altitude and it is likely that the aircraft remained in the approach configuration with insufficient power applied to maintain flying speed. In level flight, the aircraft stalled at a height from which recovery was impossible and it struck the ground in a public park approximately 1 nm from the airport. The student pilot was fatally injured. Four safety recommendations were made.

History of the flight

The student pilot was training towards the issue of a Private Pilots Licence (PPL). On the morning of the accident he attended the flying school in order to sit an Aviation Law written examination[1]. Two days previously he had successfully completed his first solo flight and the instructor intended to consolidate that exercise with

Footnote

[1] One of several written examinations that a student must pass prior to the grant of a PPL.

a dual flight in preparation for a second solo flight. After the examination, at approximately 1430 hrs, the student met his instructor to be briefed for his next flight. Following the briefing the student proceeded to the aircraft to inspect it before flight.

Meanwhile, the instructor contacted Air Traffic Control (ATC) by telephone to book out[2], spoke to the Senior Air Traffic Control Officer (SATCO)[3] and informed him that following a short dual flight, the student pilot would probably continue solo. The SATCO asked if this would be the student's first solo. The instructor replied that it would not be, but he could not recall if he advised the SATCO that it would be his second solo flight. The SATCO passed details of the intended flight to the Aerodrome Controller (ADC)[4] in the form of a Flight Progress Slip (FPS). The SATCO omitted from the FPS the number of persons on board for each portion of the flight because he considered that this could not be done without ambiguity. He did, however, explain verbally to the ADC on duty at the time that at some stage the student pilot would be sent solo.

The instructor went to the aircraft after booking out and found that the student had "completed his usual meticulous walk-round and was keen to go flying in his usual cheerful manner". Before takeoff the aircraft was prepared for flight in accordance with the normal checklist, which included an engine 'power check'. During this procedure, which involved checking the ignition system, carburettor heat and engine performance parameters, the engine performed normally. At 1449 hrs the aircraft lined up and took off from Runway 06.

The instructor considered that the student's first circuit was "text book" (ie accomplished entirely competently) but he decided to conduct a further dual circuit in order to assure himself that the student was landing the aircraft consistently. After the aircraft landed at 1505 hrs the instructor called the tower: "GOLF BRAVO BRAVO CLEAR AT ALPHA PLEASE FOR SOLO CIRCUITS", indicating that G-BABB had vacated the runway onto Taxiway Alpha (which passes the flying school at the eastern end of the airport) and that the subsequent circuits would be flown solo. The ADC replied "APPROVED". The instructor then told the student to carry out three further solo circuits and disembarked beside the flying school.

At 1508 hrs the student called the tower: "BRAVO BRAVO TAXI FOR CIRCUIT SOLO CIRCUIT PLEASE"[5]. He was instructed to taxi to Holding Point C1, at the south-west end of the aerodrome. He was not required or expected to carry out a further power check and there is no evidence to suggest that he did so.

At 1510 hrs the ADC who had been on duty during the dual flight handed over to another controller. There is no record of the information exchanged during this verbal handover, but, in the opinion of the SATCO, the relieving ADC may not have been aware at this stage that the pilot of G-BABB was an inexperienced student. Moreover, the ADC himself stated that he had not been made aware of this fact.

At 1512 hrs the ADC received from London Terminal

Footnote

[2] A formal requirement, in which the commander of an aircraft gives ATC details of the intended flight, including the nature of the intended flight, and number of persons on board.

[3] The SATCO was manning the Air Traffic Control Assistant support position in the visual control room.

[4] The arrangement of air traffic services at Southend is explained later in this report under the heading **Communications**.

[5] The text of all communications on the tower frequency is taken from the Certified Recorded Speech Transcript covering the period 1508 to 1528 hrs on 19 July 2006.

Control Centre (LTCC) a release for a BAe 146 airliner which had been waiting to depart from Southend on a flight into controlled airspace. This enabled the ADC to give the BAe 146 a departure clearance and, subsequently, clearance to take off. At 1516 hrs, in his first exchange with the new controller, the student reported that he was holding at C1 and was instructed to hold position. The BAe 146 commenced its takeoff roll from the beginning of Runway 06 at 1517 hrs and departed.

Light aircraft such as G-BABB would usually commence their takeoff roll from the intersection of Holding Point C1 with Runway 06. Although this is 376 m from the start of the runway, it still permits a takeoff run of 1,083 m, which is considerably more than G-BABB required in the prevailing conditions. However, the departure of a light aircraft such as G-BABB following a larger aircraft such as the BAe 146 must be delayed in order for the disturbance of the air in the wake of the preceding aircraft ('wake turbulence') to diminish. In this case the minimum spacing is two minutes if both aircraft depart from the same point, or three minutes if the following aircraft departs from an intermediate point. Accordingly, as G-BABB approached the holding point, the ADC instructed the student "TO MINIMISE VORTEX DELAY RUNWAY 06 ENTER BACKTRACK LINE UP", intending that the student should enter the runway and taxi to the beginning of Runway 06. When, after a short delay, the student had not replied, the ADC repeated the instruction. The student then read back "BRAVO BRAVO ZERO SIX BACKTRACK".

Later, when the ADC saw that, rather than entering the runway as instructed, the student had manoeuvred the aircraft at the holding point until it was facing back along the taxiway in a north-easterly direction, he transmitted "GOLF BRAVO BRAVO ER REPORT YOUR INTENTIONS". The student responded "BACKTRACK RUNWAY ZERO SIX", to which the controller replied "ER YEAH YOU'RE NOW FACING TOWARDS THE TOWER", and shortly afterwards "GOLF BRAVO BRAVO JUST ENTER THE RUNWAY AND LINE UP AS NORMAL". Fifty seconds later the student replied "BRAVO BRAVO LINING UP", to which the ADC responded "GOLF BRAVO BRAVO ROGER LINE UP AND WAIT JUST A SHORT DELAY NOW FOR VORTEX ONE FURTHER MINUTE". The student replied "BRAVO BRAVO LINING UP".

At 1520 hrs the ADC transmitted "GOLF BRAVO BRAVO LEFT HAND CIRCUIT ZERO SIX CLEARED FOR TAKEOFF SURFACE WIND ZERO EIGHT ZERO DEGREES EIGHT KNOTS". The student replied "BRAVO BRAVO CLEAR TAKEOFF LEFT HAND CIRCUIT". At the time there were no other aircraft in the circuit at Southend Airport.

The instructor watched the student's flight from the flying school and listened to transmissions on the tower frequency. He considered that the flight was progressing normally and that the aircraft was maintaining the correct height.

Meanwhile, the Approach Controller (APC) had received from the London Terminal Control Centre details of N347DW, a Piper PA-46T Malibu Meridian[6], which was arriving from controlled airspace to the south. The APC identified this aircraft on radar when it was southeast of the Detling VOR beacon, 16 nm south of Southend, but it was not released to the APC's control until it was approximately 8 nm from Southend which represented about two minutes flying time.

Footnote

[6] The Meridian is a high performance light aircraft with a single turboprop engine. N347DW commenced its approach at a speed of over 120 kt. The normal approach speed of G-BABB was approximately 60 kt.

At 1523 hrs the student pilot reported "BRAVO BRAVO DOWNWIND" to which the ADC responded " GOLF BRAVO BRAVO NUMBER ONE REPORT FINAL ZERO SIX" and the student read back "BRAVO BRAVO REPORT FINAL NUMBER ONE".

At 1526:00 hrs the aerodrome and approach controllers started discussing the co-ordination of circuit traffic and the arriving aircraft. At 1526:10 hrs the ADC stated "THE CESSNA" (G-BABB) "IS TO ROLL BUT OBVIOUSLY HE'S GOING TO BE SLOW DOWN FINAL". The APC replied "I THINK YOU MIGHT HAVE TO SEND THE OTHER ONE" (G-BABB) "AROUND". The ADC responded "JUST TURN HIM" (N347DW) "THE LONG WAY ROUND ON FINAL" this manoeuvre would have increased the separation between the Piper and the Cessna. The APC replied "YEAH I'M JUST A BIT WORRIED ABOUT ALL THESE UNKOWNS" referring to aircraft in the vicinity of Southend which were visible on primary radar but with which she had no communication and no altitude information. The ADC acknowledged this message but made no further comment.

At 1526:30 hrs the student reported on final; the positions of the two aircraft when the student pilot reported on final approach is shown in Figure 1. The ADC replied "GOLF BRAVO BRAVO ROGER AND ER MAINTAIN RUNWAY CENTRELINE BUT GO AROUND ER CIRCUIT HEIGHT ONE THOUSAND FEET THERE'S FAST TRAFFIC BEHIND TO LAND". The student replied "BRAVO BRAVO MAINTAIN CENTRELINE". At this stage the ADC was concerned that N347DW's high speed might result in it having to go-around beneath G-BABB, a situation he considered dangerous and which he intended to resolve before it could occur. Consequently the ADC replied "ER GOLF BRAVO BRAVO DISREGARD THAT JUST TAKE A LEFT TURN AND FLY NORTH I'LL CALL YOU BACK IN VERY SHORTLY". At that moment the APC asked the ADC "DO YOU WANT ME TO TURN HIM AWAY" ("him" in this context being N347DW). The ADC replied "NO". The APC asked "ARE YOU SURE" and the ADC replied "YEAH".

Also at 1526:30 hrs the APC asked the commander of the Malibu "NOVEMBER SEVEN DELTA WHISKEY DO YOU HAVE THE AIRFIELD IN SIGHT". He replied "HAVE THE AIRFIELD IN SIGHT ER TURNING FINAL SEVEN DELTA WHISKEY". At 1526:40 hrs the APC transmitted "SEVEN DELTA WHISKEY ROGER THERE IS CESSNA TRAFFIC AHEAD OF YOU RANGE OF ONE MILE CLEARED VISUAL APPROACH AND ER CONTINUE" to which the commander replied "SEVEN DELTA WHISKEY ROGER". Ten seconds later the APC transmitted "NOVEMBER SEVEN DELTA WHISKEY THAT CESSNA TRAFFIC COMMENCING A GO-AROUND AND ER CONTINUE APPROACH" to which the commander replied "SEVEN DELTA WHISKEY LOOKING FOR THE TRAFFIC AND CONTINUE THE APPROACH". At 1527:00 hrs the APC instructed the Malibu commander "NOVEMBER SEVEN DELTA WHISKEY CONTACT SOUTHEND TOWER ONE TWO SEVEN SEVEN TWO FIVE" and the commander acknowledged this instruction.

Meanwhile, having received no reply to his previous instruction to G-BABB, at 1527:00 hrs the ADC transmitted "GOLF BRAVO BRAVO JUST TO CONFIRM TURN NORTHBOUND NOW". Shortly afterwards, having still received no reply, the controller called "GOLF BRAVO BRAVO TURN NORTH CONFIRM". The student replied "BRAVO BRAVO TURN NORTH". The controller responded "THANKS I'LL BRING YOU BACK IN BEHIND THE OTHER TRAFFIC THANKS FOR YOUR HELP". Moments later, N347DW called the tower frequency and announced "SOUTHEND TOWER JETPROP THREE FOUR SEVEN DELTA WHISKEY WITH YOU FOR ZERO SIX WE HAVE THE ER TRAFFIC

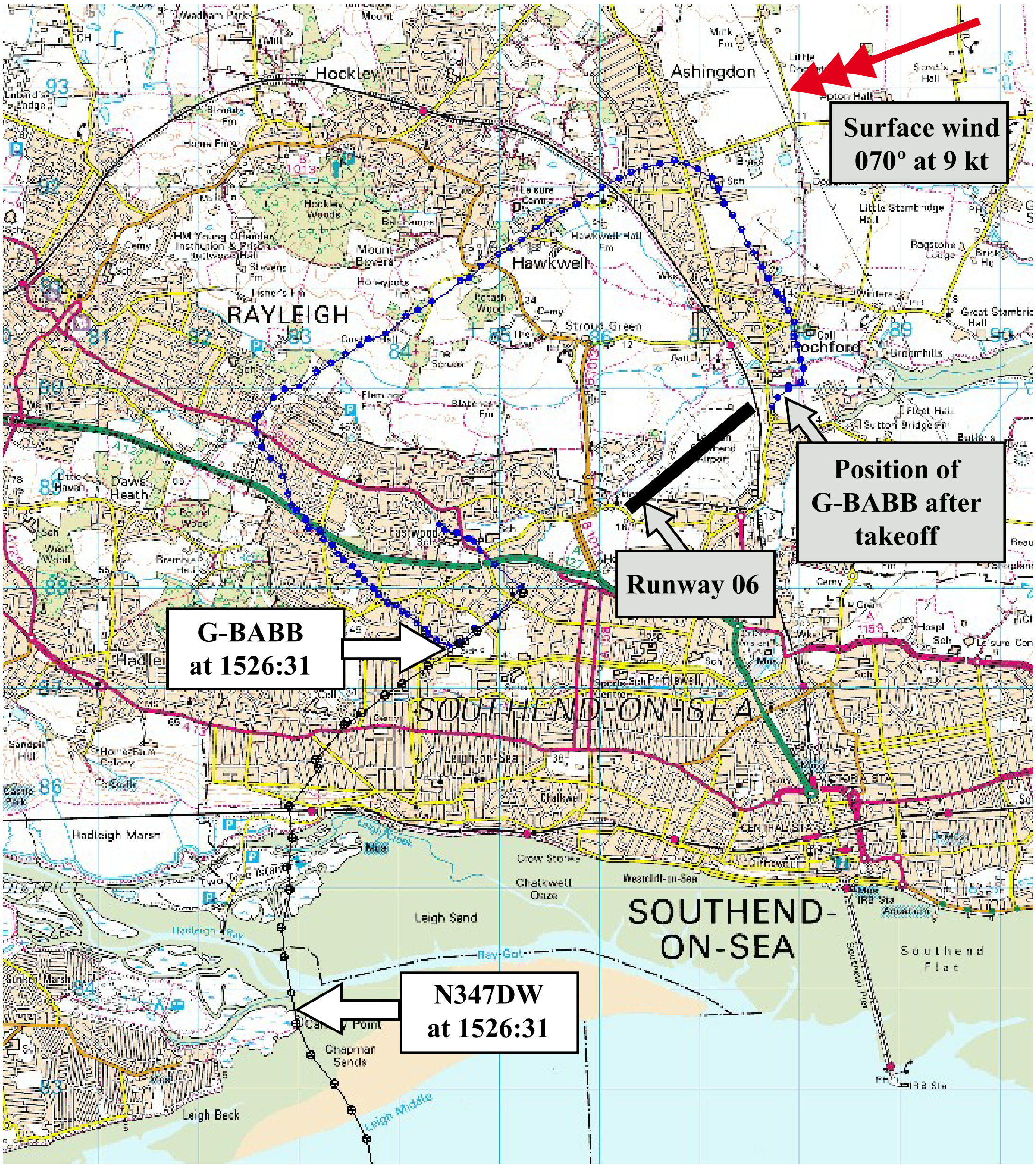

Figure 1

Locations and tracks of G-BABB and N347DW at 1526:31 hrs

IN SIGHT ON ER GO AROUND". The ADC replied "NOVEMBER THREE FOUR SEVEN DELTA WHISKEY SOUTHEND TOWER GOOD DAY RUNWAY ZERO SIX YOU'RE CLEARED TO LAND THE SURFACE WIND ZERO SEVEN ZERO DEGREES NINER KNOTS". The Malibu pilot read back the landing clearance correctly.

At 1527:40 the ADC transmitted "GOLF BRAVO BRAVO YOU CAN TU- (*part word*) MAKE ER A LEFT TURN AND ORBIT BACK ONTO FINAL APPROACH". The student replied "GOLF BRAVO BRAVO MAKE LEFT HAND TURN ONTO FINAL APPROACH".

The instructor recalled becoming anxious that visibility was reducing in bright sunshine and haze. He was also concerned that the student would have been unfamiliar with the instruction to turn north away from the final approach track and might find it bewildering. He decided that when the student had turned back onto final he would telephone the tower and request that G-BABB be instructed to make a "full stop" landing (intending that he should not conduct further circuits). Using binoculars he watched the aircraft fly away from the final approach track in what appeared to be the opposite direction to base leg, at lower than normal circuit height with what he considered to be a nose-up attitude and low airspeed. He then saw the aircraft reverse direction with a high rate of turn before entering a spiral dive, from which he considered there was no possibility of recovery.

The aircraft was seen by several witnesses to descend vertically into Eastwood Park, a public park approximately 0.5 nm north of the final approach track, where it struck the ground still rotating. The student pilot was fatally injured.

The instructor telephoned the SATCO to advise him that the aircraft had crashed. The SATCO immediately pressed the "crash button" to alert the Aerodrome Fire and Rescue Service (AFRS), who responded immediately by requesting the whereabouts of the accident site. The SATCO also telephoned 999 to alert local authority emergency services but he experienced a delay of approximately 60 seconds before being connected. Nevertheless, local emergency services were in attendance by 1535 hrs. The AFRS arrived five minutes later.

Damage to the aircraft

The accident site was surrounded by a residential area. The ground was hard and dry and the aircraft came to rest on the front of the engine and its main wheels with the tail in a near vertical position. The nose wheel with its fork assembly was found approximately 40 m behind the aircraft. Transparent plastic from the cockpit windows and other items from the cockpit were lying randomly around the aircraft out to a distance of 18 m. Both wings had sustained extensive compression damage along the leading edges and the outer portion of the left wing tip had bent upwards and backwards. The wing flaps were extended by approximately 24° relative to the wing trailing edges. The tail assembly was undamaged but the rear fuselage was creased and buckled. Whilst both fuel tanks had fractured, approximately 2 gallons of clean fuel was recovered from each tank. The engine mounting frame had buckled and failed due to impact forces. Both propeller blades had bent backwards and the propeller flange on the crankshaft had also failed through a combination of bending and torsional loads. Ground marks indicated that the propeller stopped almost immediately after it struck the ground. The cockpit was severely disrupted and the control columns had broken in several places. The magneto switch key had snapped off and the switch was found at the RIGHT (magneto) position. The throttle control was bent and had been pulled out by approximately 61 mm. The carburettor heat control had been pulled out by approximately 22 mm and the mixture control was pushed fully in (the RICH position). The pilot was wearing an intact three-point harness providing lap and diagonal torso restraint.

The damage to the aircraft and ground marks indicated that the aircraft struck the ground at a very steep angle, left wing first. The aircraft then rotated slightly to the left before tilting back onto its mainwheels.

Meteorological information

The weather report for Southend Airport, valid at 1520 hrs, indicated a surface wind from 060° at 9 kt with visibility in excess of 10 km and no cloud with a base below 5,000 ft. The surface temperature was 28°C and the dew point was 17°C. The surface wind, reported by the ADC to N347DW 30 seconds before the last transmission from G-BABB, was from 070° at 9 kt. An aftercast produced by the Met Office indicated a wind at 500 ft from 120° at between 10 and 15 kt and a surface wind varying between 060° and 120° at 10 kt. The aftercast did not consider local wind effects such as sea breezes.

Communications

At the time of the accident ATC at Southend Airport used two frequencies: The ADC used one frequency (callsign Southend Tower) to provide aerodrome control services and the APC used the other (callsign Southend Radar) to provide approach control services.

The Manual of Air Traffic Services (MATS) Part 1 defines the responsibilities of aerodrome control as follows:

> *'Aerodrome control is responsible for issuing information and instructions to aircraft under its control to achieve a safe, orderly and expeditious flow of air traffic and to assist pilots in preventing collisions between:*
>
> *a) aircraft flying in, and in the vicinity of, the aerodrome traffic zone;*
>
> *b) aircraft taking off and landing;*
>
> *c) aircraft moving on the apron;*
>
> *d) aircraft and vehicles, obstructions and other aircraft on the manoeuvring area.'*

According to the same document, an air traffic unit shall provide approach control services to aircraft from the time and place at which they are released by area control (in this case LTCC) until control is transferred to aerodrome control. Outside controlled airspace, an air traffic control unit shall provide approach control services to arriving aircraft which place themselves under the control of approach control until control is transferred to aerodrome control.

In addition MATS Part 1 states:

> *'Approach control shall co-ordinate with aerodrome control:*
>
> *a) Aircraft approaching to land; if necessary requesting clearance to land.*
>
> *b) Arriving aircraft which are to be cleared to visual holding points.*
>
> *c) Aircraft routeing through the traffic circuit.'*

On the day of the accident the controllers manning each frequency were seated approximately 3.5 m apart in the same room of the control tower building and communicated through their headsets using an intercom which could not be heard on either frequency. This enabled the two controllers to coordinate their efforts without interrupting transmissions on the two control frequencies.

A dedicated telephone line between Southend ATC and LTCC allowed information about traffic arriving from or departing to controlled airspace to be passed between the two agencies. The approach controller commented that it was common for LTCC to advise Southend about aircraft inbound from controlled airspace when such aircraft were already very close to the airport. This was the case with N347DW.

The flying school was equipped with a radio which enabled instructors to listen to communications between aircraft and ATC on the tower frequency. The radio was capable of transmitting on that frequency, but the Chief Flying Instructor stated that in order to communicate with a student, it would be necessary to 'go through ATC at an opportune moment'. In practice this meant contacting ATC by telephone. Instructors were not permitted to contact students directly using this radio.

Eyewitness statements

Witnesses observed the accident from several viewpoints in and around Eastwood Park and from the Airport. All reported seeing the aircraft flying level in a northerly or north-westerly direction with a nose-up attitude prior to its final descent. Those who lived nearby and were accustomed to seeing light aircraft operating around Southend commented that it was lower than usual. One witness, who in the course of training some years ago had made an approach to Runway 06, saw the accident from a position beneath the flight path of G-BABB and stated that he believed the aircraft to be flying at right angles to the approach path, at or below the normal glide path[7] (which would be approximately 300 ft agl at that point). He had not previously seen an aircraft in that location, flying in that direction at a similar altitude. He stated that it had a "substantial nose-up attitude", suggesting that "the pilot was attempting to maintain lift at a low airspeed... the aircraft looked like it was going to stall".

Immediately before its final descent the aircraft was seen to climb slightly or raise its nose before the left wing dropped. The nose of the aircraft then dropped and it entered a vertical dive with some rotation. Most witnesses who saw the aircraft in its final descent observed it to be rotating anti-clockwise (in a left turn as viewed from above).

One witness reported that, from her garden approximately 1 nm south of the accident site, she saw an aircraft proceeding north at low height. She commented that it appeared to be under the control of the pilot but that the engine, which was very noisy, sounded as though it was "cutting out". Another witness who watched the aircraft from beside Beaver Tower[8] reported that the propeller slowed down very rapidly as the aircraft entered the spiral dive. A further witness, who was standing approximately 200 m south of the accident site, stated that the engine stalled after the aircraft entered the spiral dive.

Several witnesses closer to the accident site who were familiar with the sight and sound of light aircraft mentioned that aircraft sometimes "cut their engines" when landing at Southend. One witness, who watched the aircraft from his garden 0.3 nm from Eastwood Park, estimated that it had flown past his house at approximately 300 ft. He considered that the engine note seemed steady with no misfiring. He noted, however, that "the engine note sounded more like cruise power than full power". Two witnesses near to the accident site, who both commented that aircraft landing at Southend often appeared to be using low power, thought that the aircraft was quieter than usual.

The pilot of the Piper, N347DW, reported that he could see a Cessna during his approach to land. He recalled thinking that the spacing was going to be "pretty tight" if the Cessna was going to make a full stop landing because his aircraft had a faster approach speed. He estimated the separation to be between 1 and 1.5 nm. He then saw the Cessna "break off" the approach and make a left turn. He assumed it was conducting practice approaches and had executed a missed approach. He then focused on his own landing and lost sight of the Cessna.

The SATCO stated that he saw the aircraft turn northbound, in a position slightly north of the normal final approach track, adding "it seemed very low and I had the impression that the flaps were still extended". He added the aircraft "had the nose pointing as if to

Footnote

7 Aircraft approaching Runway 06 at Southend would normally follow a vertical path making an angle of approximately 3° with the horizontal.

8 A block of flats at the western edge of Eastwood Park.

climb; it was noticeably having difficulty in attaining any significant rate of climb".

Recorded information

National Air Traffic Services provided recordings from Stansted Airport of radar returns corresponding to G-BABB, starting at 1521:11 hrs at the north-easterly end of Runway 06. Altitude data were not recorded.

A radar return recorded at 1527:09 hrs confirmed that when G-BABB was 0.82 nm from the Runway 06 threshold, N347DW was 1.20 nm from G-BABB. The aircrafts' positions are shown in Figure 2.

The next radar return from G-BABB was recorded at 1527:24 hrs. Several returns were missing around the time of the instruction to turn north which reduces the resolution of this position. After the instruction to turn north there were seven further recorded points which showed G-BABB tracking north-west. Due to the tolerances of the radar recording system, it was not possible to calculate an accurate instantaneous groundspeed towards the end of this flight. However, after applying the surface wind reported to N347DW of 070º/09 kt to the radar derived groundspeeds, the aircraft's average true airspeed on final approach was 69 mph (60 kt) whereas its average true airspeed on its north-westerly track was 54 mph (47 kt). Computations were also carried out using the aftercast 500 ft mean wind of 120º/12 kt; these produced likely average speeds of 67 mph (58 kt) on final approach and 46 mph (40 kt) on the north-westerly track.

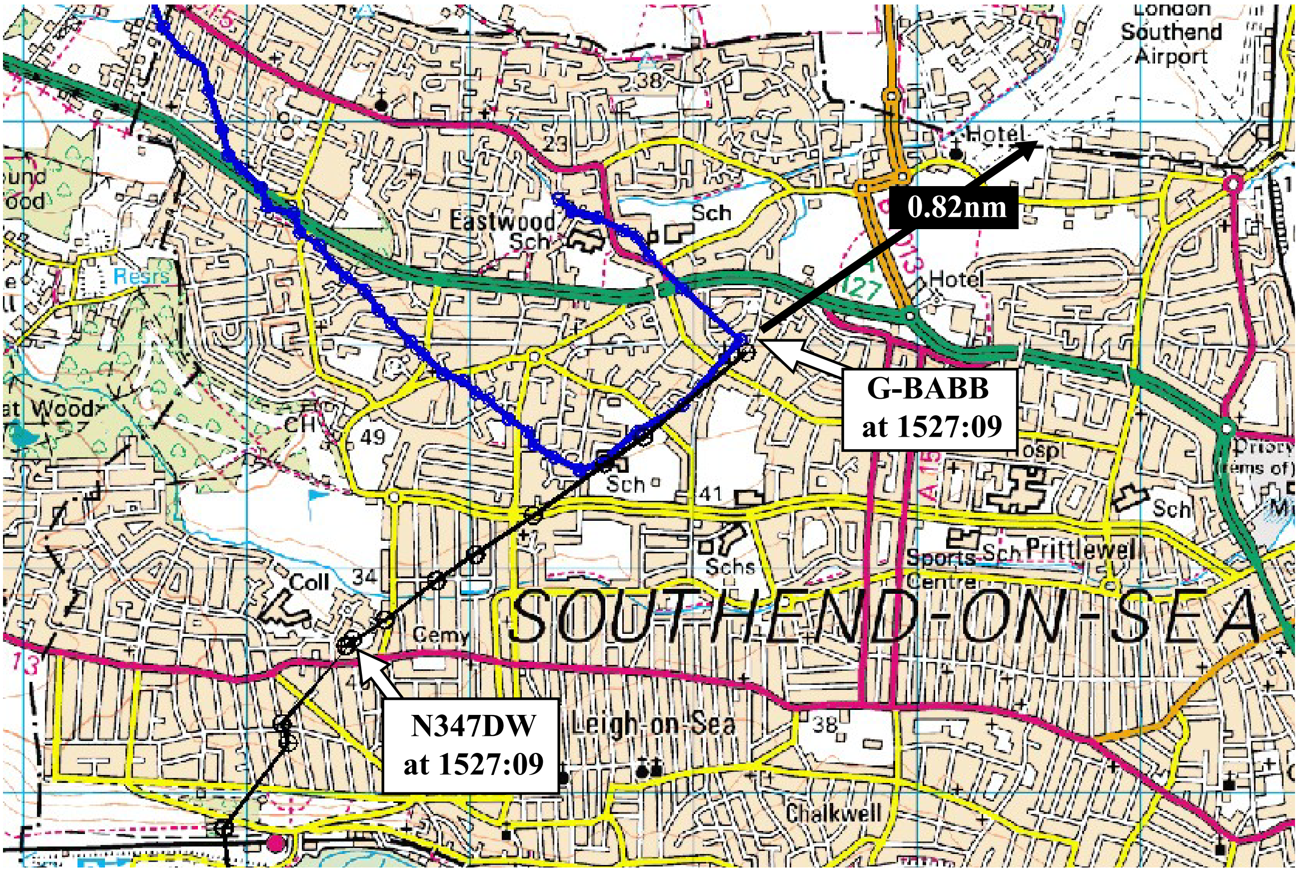

Figure 2

Locations of G-BABB and N347DW at 1527:09 hrs

The last radar return from N347DW, recorded at 1527:47 hrs, indicated that the aircraft was 0.82 nm from the runway threshold. Again, some returns were missing, including an 11.25 sec gap between the penultimate and last points. The final radar return from G-BABB, recorded at 1527:51, indicated that it had continued in a north-westerly direction. The wreckage was found 170 m to the south-west of the final radar return.

Personnel information

Aerodrome controller (ADC)

The ADC on duty at the time of the accident gained his initial Aerodrome Instrument Controller rating in 2000 and an Approach Control Procedural rating in 2001. He completed an Approach Control Surveillance rating in 2004 and started work at Southend Airport, in 2005. At the time of the accident his qualifications were current and appropriate to his duties. The ADC also possessed a United Kingdom PPL issued in 1996.

On the day of the accident the ADC arrived for work at 1215 hrs. Having been on leave for two weeks, he reviewed the ATC memorandum file and operational instructions before taking over the aerodrome control position at 1300 hrs. He remained at that position for approximately one hour before taking a meal break. He then returned to the aerodrome control position at 1510 hrs.

Approach controller (APC)

The APC had worked at Southend throughout her career as an air traffic controller. She gained her initial Aerodrome Instrument Controller rating in 1998, an Approach Control Procedural rating in 2001 and an Approach Control Surveillance rating in 2004. She was also an "On the Job Training Instructor", authorised to supervise other controllers in a live air traffic environment. The APC also possessed a United Kingdom PPL issued in 1993.

On the day of the accident the APC started work at 0800 hrs. Before lunch she operated the aerodrome control position but after lunch she operated the approach position. At the time of the accident her qualifications were current and appropriate to her duties.

Flying instructor

The flying instructor who authorised the solo flight had been the student's only instructor throughout his training. He had been flying at Southend for approximately 25 years; he joined the flying school in 1991 as an instructor and had held the post of Chief Flying Instructor before becoming a freelance flying instructor. He held a 'Flight Examiner Ground Examiner (Private Pilot Licence)' rating, authorising him to conduct: skill tests for the issue of a PPL; skill tests and proficiency checks for the issue, revalidation and renewal of class and type ratings on single-pilot aeroplanes; flight tests for the grant and renewal of IMC ratings; ground examinations for the grant of a PPL. This rating was valid until 30 September 2008. During his most recent Instructor Rating assessment, carried out on 24 May 2006, he was found to meet the appropriate requirements for this rating. He possessed a current Class One medical certificate, valid until 16 September 2006. At the time of the accident his qualifications were current and appropriate for the instructional flight.

Aircraft information

The Cessna 150L is a high wing twin-seat aircraft equipped with a four-cylinder piston engine and a two-bladed propeller. Fuel is supplied to the engine from two tanks, one mounted in each wing. The fuel flows under gravity through a fuel shut-off valve to an engine-driven fuel pump which provides fuel under pressure to the carburettor. The aircraft is equipped with conventional flight controls operated by pulleys and cables. The trailing edge flaps are operated electrically and controlled by a three-position flap selector switch located to the right of the centrally mounted engine controls. To select flaps DOWN the switch must be held down and released when the required amount of flap is obtained. There are no detents to provide exact positioning and so to position the flaps it is necessary to monitor a position indicator located in the left door forward post. To select flaps UP the switch is moved to the UP position; the switch will remain in this position unless it is moved to the OFF position. Gradual flap retraction can be accomplished by intermittent operation of the flap switch between the UP and OFF positions. The aircraft is fitted with a stall warning device which is not dependent on either a switch or electrical power; the warning horn is operated by air pressure sensed at the leading edge of the wing.

Detailed examination of wreckage

General

All the damage to the aircraft was consistent with the aircraft hitting the ground. Continuity of the flying controls was established and there was no evidence of a control restriction. Whilst the aperture of the stall warning sensor had been damaged in the crash, the hose to the horn was intact and the horn made a loud noise when suction was applied to the hose. An instructor who introduced another student to slow speed handling three days before the accident flight reported that during the lesson, the stall warning horn operated normally. The pitot probe had snapped off and parts of the pressure hose in the cockpit area had been damaged in the crash. However, as far as could be determined, the hose between the pitot probe and the ASI was intact. The ASI dial was marked in mph; its needle moved full scale and returned to zero when air pressure was applied at the inlet but damage to the instrument rendered calibration impractical. The flap screw jack had extended by 96 mm which the aircraft manufacturer stated was consistent with a flap setting of approximately 20º. The key in the magneto switch had broken off and the switch was found in the second of four positions; that position corresponded to RIGHT MAGNETO ON. The side of the engine air intake duct, which had been badly distorted in the crash, was cut away and it was established that carburettor heat had been selected ON at the time of the accident. The glass on the engine rpm gauge had broken. Both the face and the gauge's internal mechanism had been damaged causing the needle to freeze at 900 rpm. There was also an impact mark on the face of the gauge caused by the tail of the needle striking the face during impact, which again corresponded to an engine speed of 900 rpm.

Fuel

The fuel lines were intact and the fuel selector valve was in the ON position. Compressed air passed freely through the valve indicating there was no restriction in the valve. Fuel was found in the pipes on either side of the selector valve and there was no evidence of debris in any of the fuel system components.

The aircraft was last refuelled at 1805 hrs the day before the accident and had since flown 1.3 hours. Therefore it was estimated that at the start of the accident flight, there would have been approximately 18 USG of fuel in the tanks, which would have been sufficient for approximately 2.4 hours of flying. Fuel samples from each of the fuel tanks and the bowser from which the aircraft was last refuelled were analysed by the QinetiQ fuels laboratory. All the samples were found to be of an acceptable standard.

Engine

The engine was taken to a specialist overhaul facility were it was stripped. Several components were tested under the supervision of an AAIB Inspector.

The crankshaft could not be rotated because the forward left side of the engine casing had been badly damaged. Consequently, the engine timing could not be checked. Nevertheless, it was established that all the engine components worked correctly with no evidence of overheating or the engine having seized. Oil was found in all the galleries and no debris was found in the oil filter. The spark plugs and cylinder heads were all light grey in colour indicating that the fuel/air mixture was correct.

The carburettor was inspected and a float test carried out which indicated that the carburettor was probably working correctly at the time of the accident. The mixture lever had broken and bent in a position corresponding to the mixture lever set at RICH. The carburettor air inlet orifice had distorted in the impact but the butterfly valve, which sits inside the orifice, was undamaged. This could have only occurred if the throttle stop on the carburettor had been at least 10 mm off the idle stop. This stop is illustrated in Figure 3.

Whilst the ignition system high tension leads had been badly damaged, there was no evidence of chafing or arcing and the leads were assessed as being in good condition at the time of the accident.

The magneto timing was last checked 500 flying hours before the accident. After the accident both magnetos performed satisfactorily when run on a test rig for approximately 15 mins each. The magnetos should have been set such that their points started to open at $10 \pm 4^{\circ}$ before Top Dead Centre (TDC). However, during the examination of the magnetos it was established that the internal timing of the left magneto was 18º before TDC and the right magneto was 15.5º before TDC. The screws securing the points on both magnetos were still tight and there was no evidence that the points had moved during the crash. A current leakage test undertaken on the condenser from the left magneto revealed that the leakage was 26 microamps; the maximum permitted value is 8 microamps. Because the functional test of

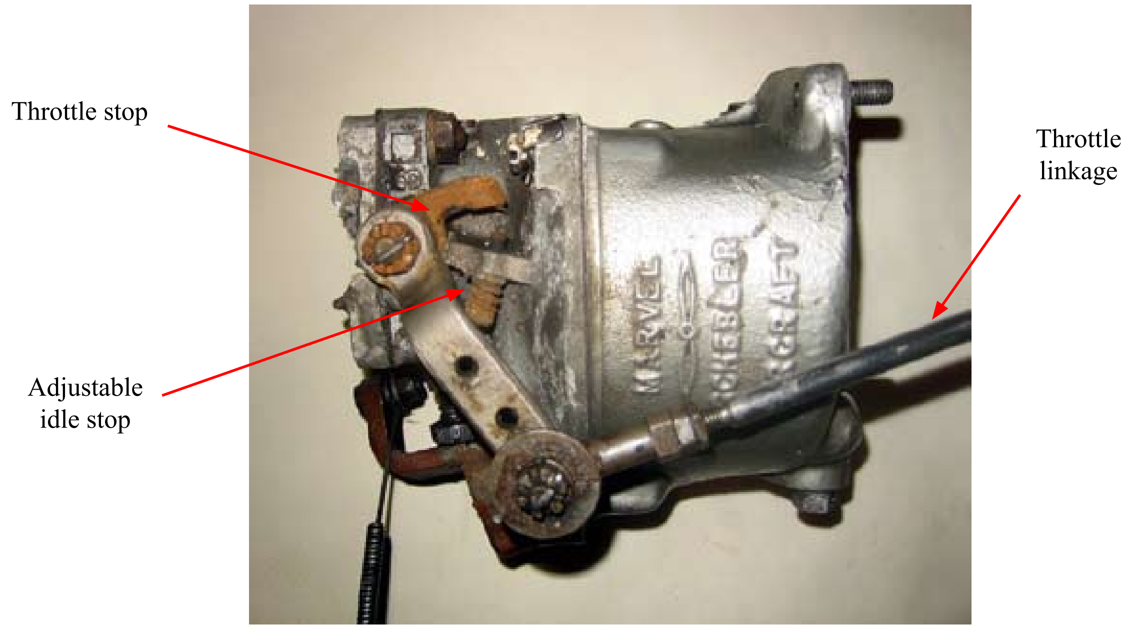

Figure 3

Carburettor removed from G-BABB
(Oxidation of the throttle stop and idle screw occurred after the accident)

the left magneto was satisfactory, the deterioration of its condenser had probably not reached a level sufficient to affect the magneto's operation.

Propeller and crankshaft flange

Damage to the propeller and the crankshaft were consistent with the blades stopping suddenly when they struck the ground.

Medical and pathological information

The student pilot held a valid Class Two medical certificate issued on 19 September 2005. Post-mortem examination confirmed that he died of multiple injuries sustained on impact. There was no evidence of natural disease which could have caused or contributed to the accident. The accident was considered to be non-survivable and it is unlikely that any additional or alternative restraint would have saved the pilot's life.

Training for a PPL

The student pilot was undertaking training towards the issue of a United Kingdom PPL (UK PPL). UK PPLs are issued in accordance with the Joint Airworthiness Requirements (JARs) as specified in the document JAR-FCL 1. Students must comply with the following:

JAR-FCL 1.085:

> *(a) A student pilot shall meet requirements specified by the Authority in the State in which the student intends to train. In prescribing such requirements the Authority shall ensure that the privileges granted would not permit student pilots to constitute a hazard to air navigation.*
>
> *(b) A student pilot shall not fly solo unless authorised by a flight instructor.*

JAR–FCL 1.090:

> *Minimum age*
>
> *A student pilot shall be at least 16 years of age before the first solo flight.*

JAR–FCL 1.095:

> *Medical fitness*
>
> *A student pilot shall not fly solo unless that student pilot holds a valid Class 1 or Class 2 medical certificate.*

Syllabus

A summary of the training course requirements is contained in JAR-FCL 1.125. Under the heading *'Flight instruction'*, Appendix 1 to JAR-FCL 1.125 states:

> *The PPL(A) flight instruction syllabus shall cover the following:*
>
> *(a) pre-flight operations, including mass and balance determination, aeroplane inspection and servicing;*
>
> *(b) aerodrome and traffic pattern operations, collision avoidance precautions and procedures;*
>
> *(c) control of the aeroplane by external visual reference;*
>
> *(d) flight at critically slow airspeeds, recognition of, and recovery from, incipient and full stalls;*
>
> *(e) flight at critically high airspeeds, recognition of, and recovery from, spiral dives;*
>
> *(f) normal and crosswind take-offs and landings;*

(g) maximum performance (short field and obstacle clearance) take-offs, short-field landings;

(h) flight by reference solely to instruments, including the completion of a level 180 degrees turn;

(i) cross-country flying using visual reference, dead reckoning and radio navigation aids;

(j) emergency operations, including simulated aeroplane equipment malfunctions; and

(k) operations to, from and transiting controlled aerodromes, compliance with air traffic services procedures, communication procedures and phraseology.

Section 2 of JAR-FCL 1 describes Acceptable Means of Compliance (AMC) associated with each requirement. The '*Syllabus of flight instruction for the Private Pilot Licence (Aeroplanes)'* contained in AMC FCL 1.125 is divided into 19 exercises in which techniques are demonstrated by an instructor and then practised by the student. Each exercise is intended to build on its precursor in order to equip a student with the practical skills necessary to operate an aeroplane safely. Exercises 1 to 13 are conducted prior to a student's first solo flight, which itself is known as Exercise 14. Early exercises teach the student the effects of the various controls in the aircraft and how to manoeuvre the aircraft on the ground and in the air. Exercises 10 and 11 give the student experience of slow flight, stalling and spin avoidance. Exercise 12 concerns the takeoff and climb to the downwind position. During Exercise 13 a student is taught procedures for flying a circuit at an aerodrome including landing, missed approach and go-around. Extracts of the relevant parts of AMC FCL 1.125 are reproduced in Appendix A at the end of this report.

Whereas Appendix 1 to JAR-FCL 1.125 indicates that students are expected to be able to operate safely within the *'traffic pattern'* (circuit), the teaching of manoeuvres intended to increase the spacing between aircraft in the circuit, other than the go-around, is not specified. Specifically, the practice of orbiting is not included in the PPL syllabus, although it is often demonstrated to students. There was no documentary evidence of the student having carried out orbits. However, the CFI of the flying school which operated G-BABB stated that "students have practice in three-sixty delaying actions downwind (orbits)" and that "orbits, extended downwind legs and go-around manoeuvres all happen as a matter of course at Southend because it's a busy circuit with big aircraft". He commented that the student involved in this accident would not have practised orbits in the approach configuration.

Student's record of training

Before the accident the student had flown for a total of 15 hours 35 mins, including 1 hour 5 mins of stall and spin appreciation (Exercises 10 and 11) on 3 April 2006 and 7 hours 10 mins of circuit training (Exercises 12 and 13). His first solo flight was on 17 July 2006 and lasted 15 mins. His training record indicated that he had made good progress throughout.

Circuit and approach technique

A diagram of a typical circuit is shown in Figure 4.

Independently of each other, the instructor and CFI described the technique which the student would have been taught for flying the base leg and final approach in a Cessna 150. On base leg he would select carburettor heat HOT, 1,700 rpm and check that the airspeed was below the 100 mph maximum speed for operating with flaps extended. He would then set 20° of flap, adjust power as necessary to maintain an approach speed of 70 mph and

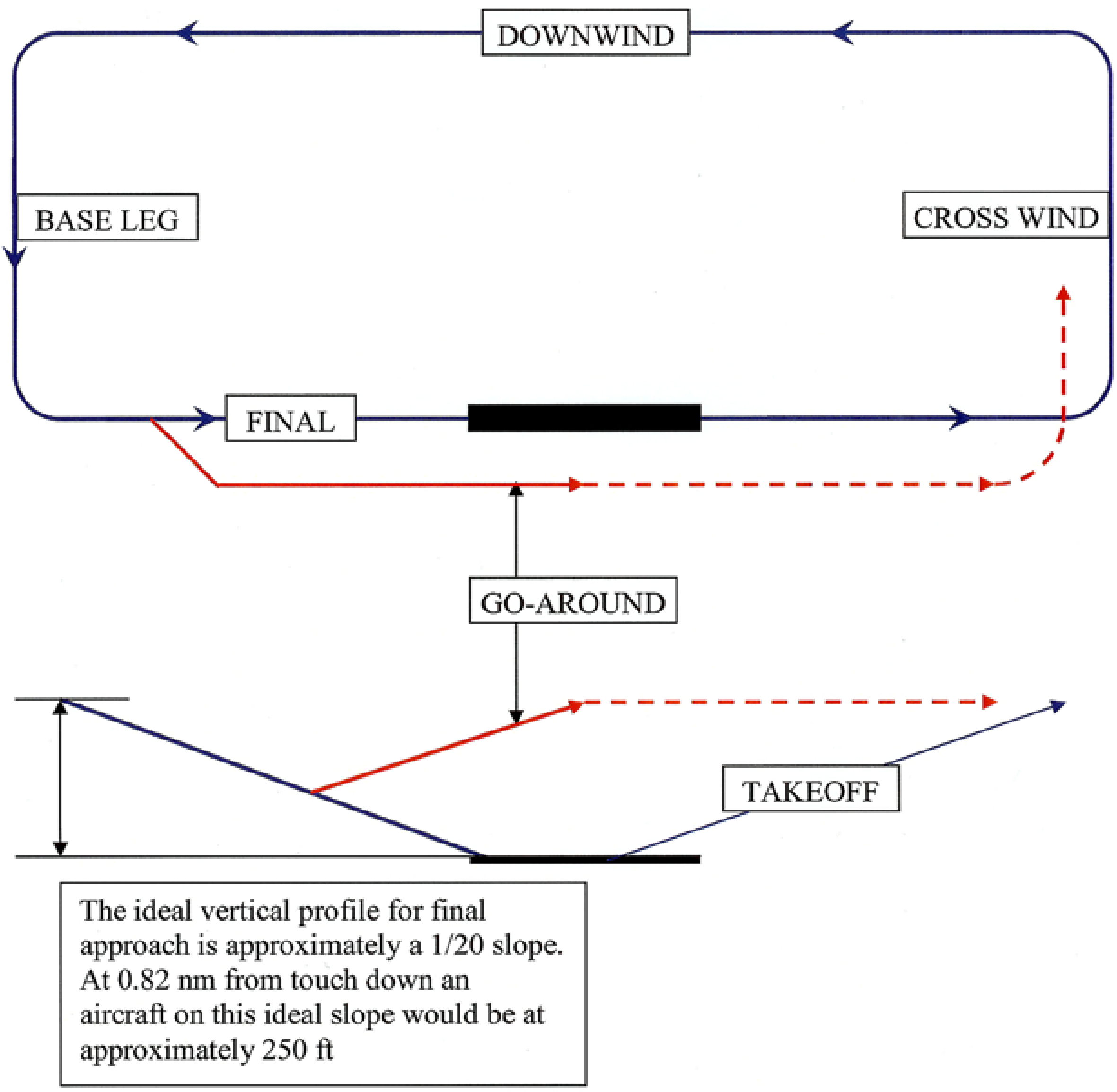

Figure 4

Typical circuit pattern

trim the aircraft. If instructed to go around, the student had been taught to apply full power, position the aircraft slightly to the right of the centreline[9], maintaining a positive climb, fly straight ahead and select the flap up in stages.

When interviewed the CFI was not aware of the configuration or manoeuvres of the aircraft immediately before impact. He commented that if the aircraft was flown level in the approach configuration with approach power set, it would eventually stall. He added that the aircraft could also drop a wing "quite viciously", particularly if it was already turning as it stalled. He also stated that without positive recovery action by the pilot, the aircraft would probably enter a spiral dive.

Footnote

[9] Students are taught that when established in the go-around from a visual approach they should fly parallel with the runway on the side of the runway opposite normal circuit traffic, so that the runway remains in view. This advice is published in commercially available flying training manuals and in *'Safety Sense Leaflet 6 – Aerodrome Sense'*.

Flight observations

As part of the investigation a Cessna F150L was flown in order to experience its handling characteristics in the approach configuration, with carburettor heat selected HOT and 20º of flap set.

A series of approaches were flown, during which it was established that engine speeds of between 1,500 and 2,000 rpm were required to maintain the ideal approach path at 70 mph IAS (61 KIAS).

Before flight, inspection of the sample aircraft revealed that opening the throttle control to the position noted in the cockpit of G-BABB corresponded to the carburettor throttle stop being 10 mm off the idle stop. This is consistent with the position of the throttle stop as found on the engine of G-BABB. In flight in the approach configuration, this throttle position resulted in an initial engine speed of 2,000 rpm, decreasing with aircraft speed. In level flight the aircraft decelerated and eventually stalled, with a high nose attitude, at approximately 42 mph IAS (37 KIAS). Approaching the stall, the IAS fluctuated by approximately ± 2 mph.

As it stalled, the example aircraft rolled quickly to the left, adopting a bank angle of approximately 60º within one second. Simultaneously, the nose dropped approximately 45º below the horizon and a high rate of descent developed. Holding the control column fully aft produced a tighter turn but no reduction in the rate of descent. Entering the manoeuvre from a turn to the left resulted in a high rate of turn as soon as the aircraft stalled. Recovery was achieved by relaxing the back pressure on the control column and applying full power, which resulted in a height loss of at least 400 ft. Without positive recovery action the aircraft entered a steep spiral dive with anti-clockwise rotation as viewed from above.

Each time the manoeuvre was repeated, the aircraft behaved in the same manner. On each occasion an audible stall warning sounded approximately 5 mph before the stall.

Owner's manual performance data

Performance information was published in the '*Cessna Model 150 Owner's manual'* for G-BABB, produced by Cessna. This manual also covered operation of the Reims manufactured Cessna F150L. The manual stated

> *'stall speeds are presented as calibrated airspeeds because indicated airspeeds are unreliable near the stall'.*

A table in the manual indicated that at a gross weight of 1,600 lbs, in standard atmospheric conditions with power off, aft CG and 20º of flap set, the aircraft would stall at 49 mph CAS (43 KCAS). In the same configuration but with 20º angle of bank, the aircraft would stall at 51 mph CAS (44 KCAS). With 40º angle of bank it would stall at 56 mph (49 KCAS). The manual did not include information enabling these speeds to be corrected for lower gross weights or higher than standard air temperatures, such as that encountered at the time of the accident. However, stall speed decreases with reducing gross weight and increases with higher air temperature.

Guidance to Air Traffic Controllers

The Manual of Air Traffic Services (MATS)

The Manual of Air Traffic Services contains procedures, instructions and information which are intended to form the basis of air traffic services within the United Kingdom. It is published for use by civil air traffic controllers and is arranged in two parts. MATS Part 1 is published by the CAA's Air Traffic Standards Department and contains instructions that apply to all United Kingdom air traffic services units. MATS Part 2 is compiled by each air traffic services unit and contains instructions that apply to that particular unit.

MATS Part 1

Section 1 page 1 of MATS Part 1 states:

> *'The Manual of Air Traffic Services contains instructions and guidance to controllers providing air traffic services. Nothing in this Manual prevents controllers from using their own discretion and initiative in any particular circumstance.'*

Appendix E of MATS Part 1 describes communication techniques and standard phraseology. Paragraph 1.3 states:

> *'Controllers may find, on occasions, that it is necessary to extend or modify phrases. However, they should take care not to confuse or prejudice the basic meaning or intention of a phrase.'*

Paragraph 5.2.2 states:

> *'Messages should not contain more than three specific phrases comprising a clearance, instruction or pertinent information. In cases of doubt, e.g. a foreign pilot having difficulty with the English language or an inexperienced pilot unsure of the procedures, the number of items should be reduced and if necessary passed, and acknowledged, singly.'*

In relation to the lists of standard phrases, paragraph 5.3.2 states:

> *'The lists are not exhaustive and controllers may have to devise additional phrases for unusual situations. However, where a phrase does exist for a particular purpose it must be used.'*

Standard phrases are given in the Attachment to Appendix E of MATS Part 1. The instruction to go around should be given as follows:

> *'go-around, I say again, go-around (instructions), acknowledge'*

Under the heading *'Flight Priorities'*, MATS Part 1 contains the following information:

> *'10.1 Normally requests for clearances shall be dealt with in the order in which they are received and issued according to the traffic situation. However, certain flights are given priority over others and the following table shows the categorisation.*
>
> *10.2 When two or more flights of different categories request clearance the flight with the highest category shall be dealt with first. Flow control procedures are implemented and actioned by the Central Flow Management Unit. A flow control priority will be allocated automatically on receipt of a flight plan.'*

The *'categorisation'* referred to accords 'normal' flights such as that conducted by N347DW a higher priority than 'training' flights such as that undertaken by G-BABB. MATS Part 1 does not contain specific advice on the priority or otherwise to be given to preceding traffic or to inexperienced pilots when conflicts such as that between G-BABB and N347DW arise.

The Air Navigation Order contains the Rules of the Air. Rule 17 – '*Rules for avoiding aerial collisions'* states:

> *'(4) Overtaking*
>
> *(a) Subject to sub-paragraph (b), an aircraft which is being overtaken in the air shall have the right-of-way and the overtaking aircraft, whether climbing, descending or in horizontal flight, shall keep out of the way of the other aircraft by altering course to the right, and shall not cease to keep out of the way of the other aircraft until that other aircraft has been passed and is clear, notwithstanding any change in the relative positions of the two aircraft.'*

Also:

> *'(6) Order of landing*
>
> *(a) An aircraft while landing or on final approach to land shall have the right-of-way over other aircraft in flight or on the ground or water.*
>
> *(b) (i) Subject to sub-paragraph (ii), in the case of two or more flying machines, gliders or airships approaching any place for the purpose of landing, the aircraft at the lower altitude shall have the right-of-way, but it shall not cut in front of another aircraft which is on final approach to land or overtake that aircraft.*
>
> *(ii) (aa) When an air traffic control unit has communicated to any aircraft an order of priority for landing, the aircraft shall approach to land in that order.'*

The Attachment to Appendix E of MATS Part 1 is a list of standard phrases. Under the heading *'Approaching visually to land'* it includes the phrases:

> *'Extend downwind number (number) to an (aircraft type and position)'*

and

> *'orbit right/left and report again (position)'*

Chapter 4, paragraph 1.8.5 of CAP 413 – '*Radiotelephony manual'*, states:

> *'It may be necessary in order to co-ordinate traffic in the circuit to issue delaying or expediting instructions'*

Chapter 4, paragraph 1.10 of the same document states:

> *'Instructions to carry out a missed approach may be given to avert an unsafe situation. When a missed approach is initiated cockpit workload is inevitably high. Any transmissions to aircraft going around shall be brief and kept to a minimum.'*

In each case, CAP 413 reiterates the standard phraseology shown in MATS Part 1. These documents do not specify or restrict the location where such delaying manoeuvres may be conducted.

MATS Part 2

MATS part 2 is produced locally and accepted[10] by the CAA. The instructions amplify and interpret, at local level, MATS Part 1 instructions. Any authorisation required by MATS Part 1 should appear in the MATS Part 2.

MATS Part 2, promulgated by Southend Airport, contains procedures specific to that aerodrome.

Footnote

[10] The word 'accepted' means that the document is reviewed by the CAA. The CAA may require alterations during the acceptance process and must approve locally sponsored alterations but it does not take responsibility for the contents.

Pertinent extracts follow:

> *'CIRCUIT FLYING*
>
> *By day, circuit flying may be undertaken at the discretion of the Aerodrome controller. Approach control is to be kept fully informed of the number of such aircraft and of any manoeuvre which departs from the normal circuit pattern.*
>
> *CO-ORDINATION WITH APPROACH CONTROL*
>
> *Aerodrome control is to keep Approach control updated of the current state of any circuit flying activity.*
>
> *CIRCUIT TRAINING FLIGHTS*
>
> *The Aerodrome controller may exercise discretion in respect of the number and variety of aircraft accepted for simultaneous circuit training flights. Factors to be taken into consideration include the forecast and actual weather, other pending movements including instrument training flights, and whether it is day or night.'*

The version of the Southend MATS Part 2 current at the time of the accident (dated 31 August 2004) contained no guidance about how to deal with inexperienced pilots such as students under training.

Southend ATC memorandums

A memorandum dated 15 April 1997 from the then Senior Air Traffic Control Officer (SATCO) stated:

> *'...club aircraft (have been) instructed to orbit or fly through final and reposition on opposite base leg. This is not an acceptable practice, particularly with club pilots, and especially those of low hours, in a situation where the aircraft is in approach configuration – ie reduced power, low airspeed and with flaps extended.*
>
> *In this situation, the pilot should be instructed to go-around. The clubs are very happy for their pilots to get this practice and that they should be encouraged to initiate a missed approach themselves.'*

The ADC stated that he had never been informed of or discovered the existence of this memorandum which was dated some eight years before he started working at Southend ATC.

On 19 July 2006, immediately after the accident to G-BABB, the advice contained in the 1997 memorandum was reiterated by the SATCO in a memorandum to Air Traffic Control Officers (ATCOs)

> *'Light aircraft on or approaching final will have limited manoeuvrability available.*
>
> *Such aircraft, particularly those with club pilots, and especially those with low hours, are not to be instructed by ATC to:*
>
> *1) Orbit on final*
>
> *2) Fly through final approach and reposition on opposite base leg;*
>
> *3) Be given any other significant manoeuvres whilst at low level (ie: below 600 ft) in the vicinity of the final approach and base leg positions.*
>
> *Any of these unacceptable practices could put the pilot in a position where the aircraft is in approach configuration – ie reduced power, low airspeed and with flaps extended, and as a result with very limited safe manoeuvrability available.*

If necessary the pilot is to be instructed to go-around using standard MATS PT 1 phraseology. Solo student pilots should be aware of this possible requirement and should be reasonably familiar with the procedure to be followed. Wherever possible, student pilots should be allowed to follow the standard circuit pattern, once making the missed approach.

Turns below 600 ft are always to be avoided unless there is an over-riding safety issue.

The AFS[11] are to be informed before a student is about to commence a 'First Solo' exercise, and also at the discretion of the flying club instructors or the duty ATCO for nervous or low-hours students.

With immediate effect, the number of POB for circuit training is to be recorded (on the flight strip). The number of POB is to be updated whenever there is a change, (ie: due to dropping off of the instructor, etc). Other pertinent information such as '1st Solo' or 'Tyro' (to denote low hours student or recently qualified) is also to be added when so informed by pilot or flying club.'

These issues were discussed in the forum of the Guild of Air Traffic Control Officers (GATCO) before the accident. The consensus was that inexperienced pilots should not be instructed to manoeuvre on or near the final approach except to go-around. Contributors suggested that it was, however, acceptable to 'orbit' aircraft at the end of the downwind leg in order to increase separation from other landing or departing traffic. They also suggested that instructors should ensure that students were familiar with this procedure, particularly at aerodromes with significant commercial air transport operations.

Footnote

[11] Airfield Fire Service.

Human factors reports

Reports addressing the circumstances of this accident were obtained from two human factors experts. One specialised in the human factors affecting pilots and the other specialised in ATC human factors. Insights from these reports are included in the analysis below.

Analysis

Aircraft

The aircraft's technical log showed that it had been regularly maintained in accordance with LAMS.[12]. Apart from an excessive left magneto drop, which occurred 28 flying hours prior to the accident flight, and which was rectified by replacing one spark plug and cleaning the others, there was no recent fault history recorded in the aircraft's technical documentation.

At the time of the accident the mixture was set at RICH, the throttle position was consistent with an approach power setting, the carburettor heat was at HOT and the flaps were set at positions consistent with an indication of approximately 20º. The ground marks and damage to the aircraft were consistent with it having stalled and entered a steep spiral dive to the left.

The magneto switch was found at the RIGHT position. Its abnormal position indicates either that it remained in this position after the magneto check, moved to that position when the aircraft crashed or the pilot moved it in flight. During the power check the student was trained to check for a drop in engine rpm when the magneto switch is rotated from BOTH to LEFT or RIGHT, and that the rpm returns to its previous value when the switch is moved back to the BOTH position.

Footnote

[12] Civil Air Publication 411 '*Light Aircraft Maintenance Schedule-Aeroplanes*'.

He probably did not carry out a second power check before taking off solo and so, under the supervision of his instructor, the switch was most probably returned to the BOTH position before the first takeoff.

The student made no mention during any of his radio calls that he was experiencing problems with the engine, which suggests that he did not move the key intentionally whilst airborne. However, experience from other accidents suggests that impact loads on the key which are sufficient to cause it to snap, can also rotate it to another position. Therefore it is possible that the ignition switch moved during the ground impact sequence of events.

Whilst the magnetos' internal timing was outside the normal tolerances, the aircraft had been flown for 500 hours since the timing was last checked. It had been flown by a number of instructors and students, none of whom had noticed any reduction in engine power. It is therefore likely that either the timing was disturbed during the accident sequence without leaving any tell-tale marks, or any reduction in power would have been negligible and would not have been a factor in this accident.

The deterioration of the condenser in the left magneto did not affect its performance when it was run on the test bed but it is not known what effect heat from a hot engine would have had on the condenser's performance. The worse case would have been a loss of the left magneto's output which would have resulted in a reduction in engine speed of between 100 and 150 rpm.

Evidence indicating whether or not the engine was producing power when the propeller struck the ground was evaluated. The speed and steep descent of the aircraft and the relatively low power output of the engine meant that it was not possible to tell from the damage to the propeller blades if the propeller had been under power or windmilling when the blades struck the ground. The rpm gauge had frozen at 900 rpm and the engine manufacturer reported that at normal approach speed the engine would windmill at a speed between 600 to 900 rpm. Although the propeller blades stopped almost immediately after they struck the ground, it would have taken slightly longer for the body of the rpm gauge to distort and freeze the needle. In this case, the frozen gauge would have captured the speed of the engine as the needle froze rather than the speed of the engine prior to impact. Therefore, it is likely that the engine speed would have been greater than 900 rpm, which indicates that the engine was probably still producing power.

The engine manufacture stated that with carburettor heat selected to HOT, there would have been a reduction in engine power output of approximately 10% at moderate power settings. Carburettor heat also adversely affects the engine acceleration. This adverse effect would have been compounded if the pilot had advanced the throttle rapidly, such that the accelerator pump in the carburettor added more fuel to an already rich mixture. The result would be an engine that would be slow to accelerate and might be heard to misfire.

The student pilot had established the aircraft on final approach before being instructed to fly north away from the final approach track. If it had been operated in accordance with the student's training, it would have been in the approach configuration with approximately 20º of flap selected and the carburettor heat at HOT. Inspection of the damaged aircraft indicated that it was still in this configuration immediately before impact. Moreover, the target airspeed on final approach in this configuration was 70 mph and the aircraft's average airspeed on final approach, as derived from radar data and the reported surface wind, was 69 mph which is consistent with the target speed. The engine speed would have been approximately 1,700 rpm unless the throttle had been opened as if for a go-around. Witnesses reported that the aircraft flew north-west at low level. If the aircraft had followed the normal vertical profile of the approach before turning north-west, it is likely that it did so at a height between 200 and 300 ft. Radar data, though inaccurate when used to determine instantaneous airspeed, indicated that the average true airspeed of the aircraft had decreased by about 15 mph after it turned north-west. By the final radar return it may have been at or close to the stall speed. The aircraft was seen to adopt an increasingly nose-high attitude before entering a manoeuvre very similar to the stall characteristics determined during this investigation.

Although the foregoing engineering analysis does not eliminate the possibility of power loss, the investigation determined that the aircraft, in this configuration, would have performed in this manner with the engine responding normally to the throttle position as found. It is therefore likely that, having configured the aircraft for the approach, the student did not change this configuration prior to the accident. It is also likely that he did not significantly alter the throttle setting immediately before or after he turned left onto a north-westerly track.

Human factors affecting the student pilot

The student pilot had received the training required by JAR-FCL1 for him to conduct the flight. However, the process of flying a visual circuit is complex. In the early stages of flying training, reliance upon a relatively easily recalled routine reduces this complexity and simplifies the judgements required. For example, the steps involved in flying the base leg and turning onto final (including flap selection and setting the power and attitude of the aircraft) should, if correctly executed, position the aircraft close to the extended centreline of the runway and in the appropriate configuration for a 3º approach. In this way, the task is made less demanding and the need for large or complicated adjustments to the flight path is minimised. The circuit routine provides a means of achieving the basic requirements so that an inexperienced pilot can build experience and gain confidence. The sequence of the routine allows the pilot to concentrate on the task immediately at hand by defining specific sections with associated activities and priorities so that, having established the aircraft on the final approach path, the pilot should be able to concentrate on maintaining the approach path until touchdown. The instruction to report on final would provide him with an assurance that this could be his main or only priority. He would expect the next stage to be landing. The benefits of the procedural routine are most significant in the early stages of solo flying when the student is fully occupied with the basics of flying and has no spare capacity for strategic thinking or expanding his awareness beyond immediate requirements. These additional tasks are known as 'airmanship'.

Due to his inexperience the student probably relied heavily on the routine he had learned for circuit flying, which would have defined his actions and expectations.

The standard phrase *'go-around, I say again, go-around (instruction) acknowledge'* is intended to provide a clear, unambiguous instruction to a pilot, which places the important information first and is designed to trigger a sequence of actions that even an inexperienced pilot would have been taught and practised. The go-around instruction was, however, embedded in the transmission and was subsequently countermanded by the instruction "…DISREGARD THAT JUST TAKE A LEFT TURN AND FLY NORTH…" At the conclusion of this exchange the student had not acknowledged the instruction to go-around, but he had read back "BRAVO BRAVO TURN NORTH".

The instruction to turn left and fly north would certainly have been unexpected. The fact that it followed other instructions that he was told to disregard may have suggested to the student a degree of urgency. He turned as instructed, but he probably had no clear idea what would follow or how he should behave. The fact that he turned onto a track of 330º (the reciprocal of the base leg track), rather than heading north as instructed, suggests that he felt constrained to remain in the circuit. The fact that he was now flying in the reverse direction to the normal circuit would have been outside his experience and possibly alarming, particularly if he was not absolutely sure that no other aircraft were in the circuit. It is likely that his capacity for constructive thought and for monitoring the state of the aircraft was reduced and it is conceivable that some of his attention was directed to searching for other aircraft in the circuit or for the "FAST TRAFFIC BEHIND". Strategies that a more experienced pilot might have adopted include:

> Re-configuring the aircraft and climbing to circuit height, then repositioning to rejoin the circuit on the downwind leg (a go-around, in effect).
>
> Re-configuring the aircraft for level flight and awaiting instructions to reposition onto final, where he could use his judgement to configure for the approach once again and start the descent.

or:

> Reconfiguring for level flight and asking ATC for clarification.

All of these strategies would require a degree of confidence that is unlikely in a student on his second solo flight, particularly one only 16 years old. When the student pilot taxied for takeoff, the ADC instructed him to backtrack, meaning that he should taxi to the end of the runway. The ADC had to repeat the instruction which, it appears, the pilot misunderstood. This exchange highlights the difficulty an inexperienced pilot has interpreting an unusual or unexpected ATC transmission and his reluctance to request clarification. Furthermore, early in training, a student pilot experiences and is supported by two authoritative voices: his instructor's and that of ATC. When the student begins to fly solo exercises, the absence of an instructor emphasises the authority of ATC. The experience of misunderstanding the instruction to backtrack may also have been unsettling.

There were, therefore, several reasons why the pilot's capacity to cope with novel demands may have been compromised. A second solo flight is an exciting experience. In addition, the experience of misunderstanding the taxi instructions may have been unsettling. Later, on final approach, he received a complex transmission that he appears to have misunderstood and was then asked to execute an unfamiliar manoeuvre. This placed him in a situation for which his training and experience had not prepared him. It is likely that without the guidance of a familiar routine his capacity for monitoring the flight instruments was reduced. His ability to think clearly about his future flight path, to prioritise his activities, and to monitor aircraft performance were probably compromised to the extent that he did not reconfigure the aircraft for level flight and did not notice the decreasing airspeed.

Human factors affecting the aerodrome controller

The ADC on duty at the time of the accident may not have been made aware that the pilot of G-BABB was an inexperienced student when he returned to the Aerodrome Control position at 1510 hrs and received a handover from the outgoing controller. The student's misunderstanding of the instruction to backtrack the runway may have been the first indication available to the ADC that the student was inexperienced. The subsequent exchange might have provided a further indication but these indications may not have been obvious to the controller.

Before G-BABB reported final, the ADC received an intercom call from the APC informing him of the approaching Piper, N347DW. The APC was reluctant to instruct this aircraft to carry out manoeuvres intended to increase spacing between it and G-BABB because of "unknown" traffic in the vicinity and suggested instead that the ADC instruct G-BABB to go-around. The outcome of the exchange was that the ADC assumed responsibility for controlling both aircraft. Aware that the distance between the aircraft was decreasing, and believing that there was insufficient time for G-BABB to land and vacate the runway ahead of N347DW, he instructed G-BABB to go-around. This instruction was not in the standard format, however, and the student did not acknowledge that a go-around instruction had been given.

The ADC reported that before instructing the pilot to turn north, he waited until the aircraft had established a positive rate of climb and appeared to be in stable flight. This does not accord with the statement made by the SATCO that the aircraft was "noticeably having difficulty" doing so.

The ADC intended that his instructions would solve the problem of the fast moving Piper catching up with the slower Cessna. The APC's reluctance to turn N347DW away was understandable given the number of aircraft in the vicinity which were visible on radar but over which the APC had no control, no communication and no indications of altitude. However, this complicated the ADC's task and forced him, at short notice, to rethink his plan. Eventually he opted to take control of both aircraft and terminated the conversation with the APC. By turning G-BABB to the north he intended to place G-BABB safely out of the way, focus attention on N347DW until it had landed and then re-direct his attention to G-BABB. However, it is likely that of the two pilots immediately involved, the pilot of N347DW, who was bound to be more experienced, would have been better equipped to deal with demanding or unusual instructions.

Procedures for handling inexperienced pilots

At the time of the accident, although instructors would inform ATC of a first solo flight, there was no agreed method of exchanging information regarding inexperienced pilots on subsequent solo flights and no specific guidance in the Southend Manual of Air Traffic Services Part 2. The memorandum issued by the SATCO following the accident partially addressed these issues but will only continue to do so while the parties concerned remain aware of its existence. Therefore, the following recommendation was made:

Safety Recommendation 2007-036

It is recommended that London Southend Airport includes information relating to the notification and handling of flights by inexperienced solo pilots in its Part 2 of the Manual of Air Traffic Services.

With regard to this recommendation the CAA stated, in a letter to the AAIB, that it believes there is merit in bringing into use a suitable prefix for student pilots, such as 'Student', 'Trainee' or 'Tyro' and that it be applied until holders are issued with a PPL. The CAA suggests that this prefix could be used on the first call to a unit, for example:

'Student G-BXLM'

and that after acknowledgement communications would revert to the normal callsign. The FPS could then be annotated accordingly, which might eliminate the potential to lose this information when handing over to another controller. Such a system has been in use in military flying, where the word 'Tyro', when included in a transmission denotes an inexperienced pilot. This word is in casual use in civilian air traffic communications but has no formal meaning. Therefore the following safety recommendations were made:

Safety Recommendation 2007-050

The Civil Aviation Authority should instigate the use of a suitable prefix, for use in civil radiotelephony, to signify a student pilot, flying solo.

Safety Recommendation 2007-051

The Civil Aviation Authority should amend the Manual of Air Traffic Services Part 1 and the Radio Telephony Manual (CAP413) to emphasise to controllers that pilots identifying themselves as students have limited ability, which must be taken into consideration when issuing instructions.

Manoeuvres intended to increase separation

Both MATS Part 1 and the Radiotelephony Manual refer to orbiting and extending the downwind leg as examples of manoeuvres that may be used to co-ordinate traffic in the circuit. Students are not required by JAR-FCL1 to have practised these manoeuvres but they are required, at the conclusion of their training, to be familiar with standard phraseology. This requirement implies that at that stage they would be able to comply with instructions to orbit, to extend downwind and to go around from base leg or final approach. It is acknowledged, however, that students conducting their first and subsequent solo flights early in their training have accumulated only sufficient knowledge to operate within a restricted environment, and instructors are trained and assessed on their ability to consider that environment before authorising a student to fly solo. In this context, the CFI of the flying school stated that students practised orbits, extensions of the downwind leg and go-arounds at Southend.

Although there was no documentary evidence that the student pilot had practised orbits and extensions, he had completed Exercise 13 which includes missed approach and go-around manoeuvres. He had also been trained to comply with those ATC clearances that might be expected after turning onto the base leg and commencing his approach to the runway. These would be: to 'continue' and await clearance to land; to 'land' having been cleared to do so; and to 'go-around'. Consequently, it is likely that he was properly prepared for the circuit environment that his instructor might reasonably have anticipated.

The CFI added, however, that the student would not have practised orbits in the approach configuration. Any aircraft configured for a stable, descending approach will require additional power to maintain speed if it is subsequently required to fly level. Consequently, although the use of non-standard phraseology probably exacerbated the student's difficulties, even a clear instruction to orbit in the approach configuration would have been problematic. Under existing provisions, air traffic controllers are not expressly prohibited from instructing this manoeuvre. Therefore, the following recommendation was made:

Safety Recommendation 2007-037

The Civil Aviation Authority should amend MATS Part 1 so that, with the exception of issuing instructions to go-around, controllers shall not issue instructions that would require an aircraft in the final stages of approaching to land to deviate from its expected flight path unless exceptional overriding safety considerations apply.

Conclusion

During his second solo flight the student was instructed to carry out an unfamiliar and non-standard manoeuvre. Presented with a situation beyond his experience, he failed to reconfigure the aircraft for level flight. The aircraft continued to fly level at a power setting which the available evidence indicates would have been insufficient to maintain flying speed, and eventually the aircraft stalled at a height from which recovery was impossible.

Appendix A

Extract from AMC FCL 1.125

'Syllabus of flight instruction for the Private Pilot Licence (Aeroplanes)'

Exercise 10A Slow flight

NOTE: The objective is to improve the student's ability to recognise inadvertent flight at critically low speeds and provide practice in maintaining the aeroplane in balance while returning to normal airspeed.

- safety checks
- introduction to slow flight
- controlled flight down to critically slow airspeed
- application of full power with correct attitude and balance to achieve normal climb speed
- airmanship

Exercise 10B Stalling

- airmanship
- safety checks
- symptoms
- recognition
- clean stall and recovery without power and with power
- recovery when a wing drops
- approach to stall in the approach and in the landing configurations, with and without power, recovery at the incipient stage

Exercise 11 Spin avoidance

- airmanship
- safety checks
- stalling and recovery at the incipient spin stage (stall with excessive wing drop, about 45º)
- instructor induced distractions during the stall

NOTE 1: At least two hours of stall awareness and spin avoidance flight training shall be completed during the course.

NOTE 2: Consideration of manoeuvre limitations and the need to refer to the aeroplane manual and mass and balance calculations.

Appendix A (cont)

Exercise 13 Circuit, approach and landing

- circuit procedures, downwind, base leg
- powered approach and landing
- safeguarding the nosewheel
- effect of wind on approach and touchdown speeds, use of flaps
- crosswind approach and landing
- glide approach and landing
- short landing and soft field procedures/techniques
- flapless approach and landing
- wheel landing (tail wheel aeroplanes)
- missed approach/go around
- noise abatement procedures
- airmanship

Exercise 12/13E Emergencies

- abandoned take-off
- engine failure after take-off
- mislanding/go-around
- missed approach

Exercise 14 First solo

- instructor's briefing, observation of flight and de-briefing

NOTE: During flights immediately following the solo circuit consolidation, the following should be revised.

- procedures for leaving and rejoining the circuit
- the local area, restrictions, map reading
- use of radio aids for homing
- turns using magnetic compass, compass errors
- airmanship