ACCIDENT

Aircraft Type and Registration:	North American P-51D Mustang, G-MSTG
No & Type of Engines:	1 Packard Motor Car Co Merlin V1650-7 piston engine
Year of Manufacture:	1945 (Serial no: 124-48271)
Date & Time (UTC):	2 October 2016 at 1434 hrs
Location:	Topcroft Farm Airstrip, near Hardwick Airfield, Norfolk
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Fatal)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	58 years
Commander's Flying Experience:	1,965 hours (of which 760 were on type) Last 90 days - 21 hours Last 28 days - 6 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was returning to a private airstrip and, on landing, bounced twice before attempting to go around. The aircraft had been subjected to a crosswind from the right during its approach and on go-around flew a flight path increasingly diverging to the left, away from the airstrip. It remained at low level until it struck a tree close to the airstrip. The passenger was fatally injured and the pilot survived with serious injuries.

There was no evidence of any aircraft system failure or malfunction which could have contributed to the accident. The accident was most likely a result of loss of directional control due to a combination of crosswind and effects of applying go-around power whilst the aircraft was at low speed.

The investigation identified other aspects concerning the safety clothing to be worn in ex-military aircraft.

History of the flight

The pilot had flown on the morning of the accident in G-MSTG with a passenger, with no problems being reported.

Later on the same day a different passenger arrived at Topcroft Farm Airstrip with members of his family for a flight to overfly a number of World War II (WWII) United States Army Air

Force (USAAF) airfields around Norfolk. The pilot briefed the passenger who was then assisted to climb into the aircraft and strap in.

The aircraft took off from Runway 28 at approximately 1348 hrs and flew north-west towards The Wash. It then flew inland to turn onto a south-easterly track near March, turning west of Eye towards Bungay and then back towards Hardwick (Figure 1).

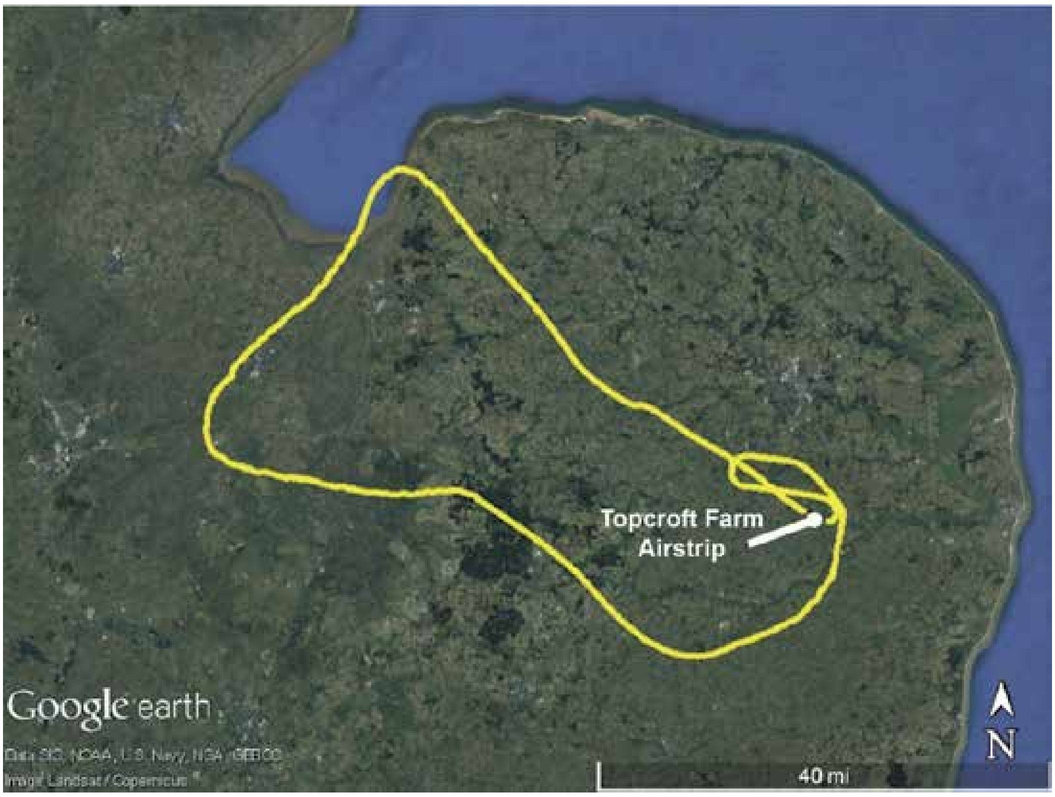

Figure 1
Radar track of G-MSTG

The aircraft neared Hardwick at approximately 1433 hrs and entered a holding pattern north-west of the airfield before joining downwind for a right hand circuit to Runway 28. The pilot then flew a continuous descending turn onto approximately a 1 km final approach. The wind at the time was reported as being from north-west/north-north-west at about 13 kt with a maximum recorded gust from north-west at 22 kt.

A witness on the airfield, standing approximately halfway along and slightly to the south of the runway, videoed the final approach and initial part of the landing. From a visual assessment of the video, the aircraft approached with its landing gear extended and flaps appearing to be fully down. The final approach seemed stable however there appeared little, if any, attempt to compensate for the crosswind by either side-slipping into wind or flying with the into-wind wing (the right wing) slightly down.

The video showed the aircraft achieve a three-point touch down and bounce back into the air. The aircraft appeared to be approximately aligned with the runway and to drift left towards the runway edge. At the same time there was a small amount of left roll which was corrected with ailerons. The aircraft then touched down again and bounced a second time; an engine rpm increase being heard on the video shortly after this touchdown. Again, the aircraft appeared to remain approximately aligned with the runway when touching down but, when airborne again, continued to drift towards the runway edge and also yawed to the left.

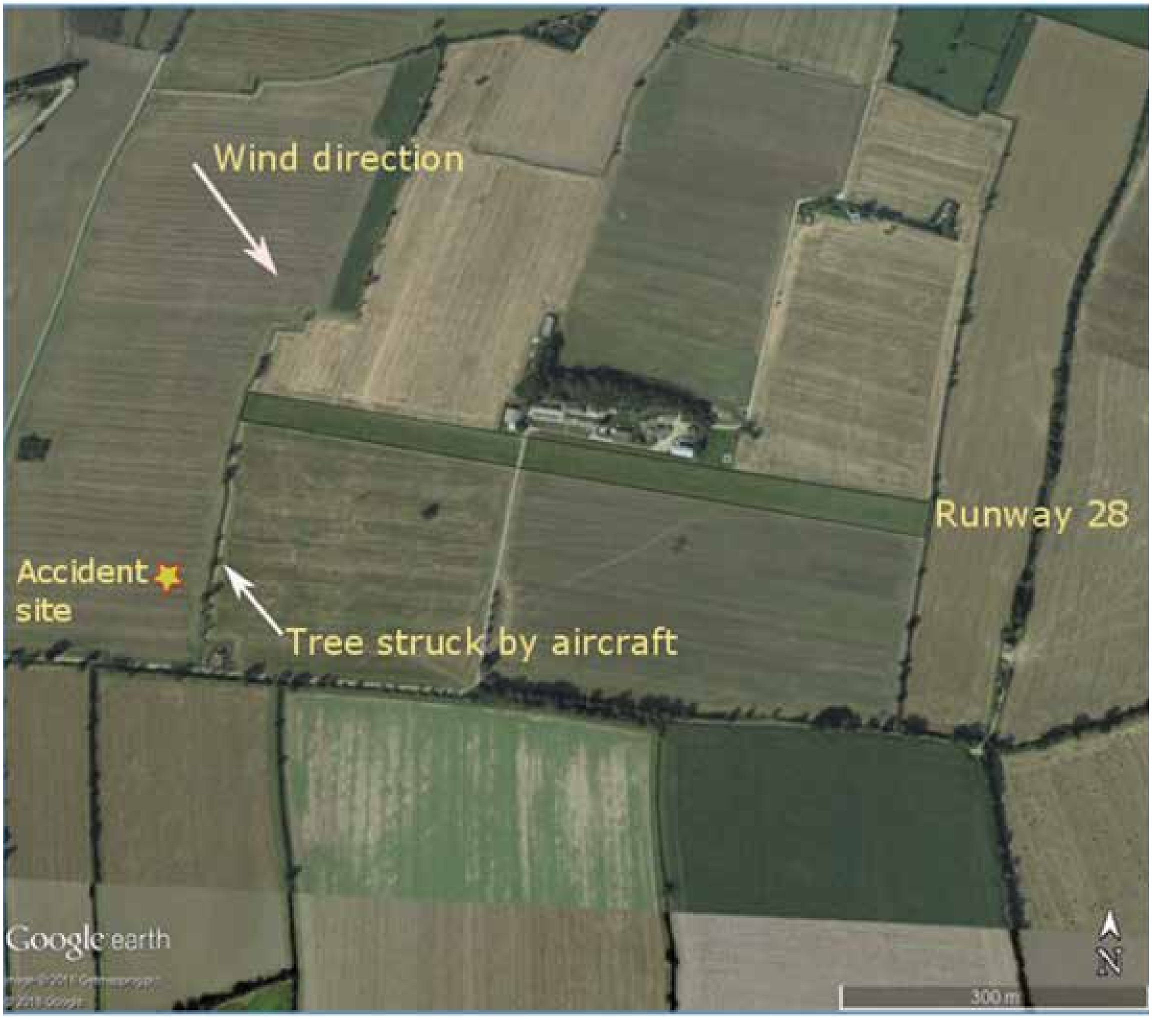

Figure 2

Topcroft Farm Airstrip

It was not possible to establish the rudder position from the video. The camera tracked the aircraft until it started to drift over the side of the grassed strip at which point the aircraft was no longer in frame, although it could still be heard in the recording.

The aircraft was seen to fly increasingly to the left of the runway, narrowly missing a tree standing in the adjacent field to the south of the airstrip. It remained at low level until it collided with a tree at the boundary of the field causing the aircraft to impact the ground. The emergency services were called and arrived on site shortly afterwards. The pilot was seriously injured and the passenger received fatal injuries.

Accident site

Figure 3
Accident site

The aircraft had struck a mature oak tree on the boundary between two fields with marks showing that one of the propeller blades had been the first point of impact. This had been rotating with sufficient power to slice upwards through the trunk and into a bough of the tree which detached and fell away. The tip of this blade was left deeply imbedded in the remainder of the trunk. After the propeller had hit the tree, the aircraft continued onward with the tree passing along the left side of the fuselage. The inner section of the left wing was struck by the tree causing the wing to detach, before the left tailplane then detached as it was also hit by the tree.

Figure 4
Tree strike in direction of aircraft travel

There was a 57 m debris trail on a bearing of 225° leading from the tree to the main wreckage. The aircraft had come to rest upright in the field beyond the tree, resting on its right mainwheel and tail wheel, with the trailing edges of the wing and tailplane tips dug into the soil.

The right wing fuel cap was in place and the tank contained approximately 25 Imp gal of fuel. Lubricating oil had seeped into the ground around the front of the aircraft and there was evidence of coolant seeping out from the underside of the fuselage.

Other than small amounts of soil residue on some of the equipment on the right side of the cockpit, all the instrument switches and controls were undamaged. The significant controls and switches were set as follows: the flap lever was set at 30 and the carburettor air control levers were set at UNRAMMED FILTERED AIR and NORMAL. The landing gear lever was set at DN and the flying control trim settings were: neutral roll, 5 units TH (tail heavy) and 2 units right rudder.

Both the throttle and rpm levers were in the fully forward position. The mixture control was set at the EMERG.F.RICH position. The supercharger switch was set to LOW, the booster pump was set to ON and the ignition (magneto) switch was set to BOTH. The fuel shut off lever was set to ON and the fuel tank selector was set to MAIN TANK LH. The RADIATOR AIR CONTROL switches for COOLANT and OIL were in the neutral OFF position. The altimeter subscale was set to 1010 hPa.

The engine was partially detached from the fuselage but bent downwards resting on the ground on the remains of the reduction gearbox. The engine bearers were broken and distorted and the engine control cables and rods were still connected but had been pulled forward and were under tension. Various oil and coolant flexible pipes had been split or had parted from their rigid pipe connections. Figure 7 shows the partial detachment of the engine and the effect on the engine control linkages.

The propeller had detached from the engine along with its drive gear and was lying in the wreckage trail close to the aircraft. All but one of the blades were complete but all were heavily distorted.

Figure 5 (right)
Propeller damage

The left tailplane was lying in a ditch near the base of the tree and the left flap and elevator was lying a short distance further on. The left wing was lying upside down in the field 65 m from the tree away from the main wreckage. The left main landing gear was still attached to the wing but was in the retracted position.

Figure 6
Left wing

The canopy had also detached and was approximately two thirds the way along the wreckage trail. Although its frame was in one piece there were signs of breakage and melting of the canopy Perspex.

Although the fuselage and engine showed little or no signs of fire, the remains of the left self-sealing fuel tank and a large portion of the tree had evidence of a brief but intense fire.

Figure 7
Engine control linkages under tension

Ground marks

The initial touchdown point of the main wheels on the airstrip could not be accurately located, however, there was a faint mark, probably from the tailwheel, 104 m in from the threshold of Runway 28 and 11 m from the left edge. There was another mark from the tailwheel 200 m further on, and 1.4 m from the runway edge at its start, running approximately 15º off the runway heading towards the left edge.

There were more wheel marks on the ploughed surface of the field next to the runway. These marks started with a tail wheel imprint and then the left mainwheel, the mainwheel mark being curved slightly to the left and approximately 100 m in length. About 29 m along the mark there was a parallel mark made by the right mainwheel. Both marks ceased as they approached the concrete track which ran across the field. There was another left mainwheel mark 100 m further on in the field on the other side of the concrete track. This mark was approximately 30 m long and was very distinctive as if the tyre had been running at an angle to the direction of travel, gouging the soil. There were no more ground marks up to the impact point with the tree. Figure 8 shows the final ground mark and the position of the tree hit by the aircraft.

Figure 8
Final tyre mark and impact tree

Aircraft background information

G-MSTG was a Mustang P51D single-engine, long-range escort fighter which was built at the end WWII in 1945 by North American Aviation. It was powered by a Packard-built Rolls Royce Merlin V1650-7 engine. It was originally delivered to the Royal New Zealand Air Force on 24 August 1945 where it remained in service to 1955. In 1958 it passed into private ownership and remained in New Zealand where it changed hands twice but was not in flying condition. In 1997, it was purchased by the pilot and entered on the CAA register as G-MSTG. The pilot oversaw a comprehensive four and a half year restoration and the aircraft had its first flight since 1958 in July 2001. The aircraft had an ANO exemption to display authentic USAAF markings ‘414419 LH-F’ rather than G-MSTG.

As is common with other privately owned Mustangs, the fuselage fuel tank behind the pilot had been removed and replaced with an approved passenger seat, harness and intercom connection; there were no flying controls or instruments fitted in this position.

G-MSTG was classified as an Annex II aircraft and certified in its current configuration on a CAA permit to fly, valid to 19 August 2017.

Aircraft description

The P51D is an all-metal, low-wing monoplane with conventional mechanical flying controls. The landing gear is of a tail drag design and all three gear wheels are retractable.

One of the engine types used to power the P51D was the Packard Merlin V12 supercharged engine, which is rated at 1600 HP. The engine controls consist of three levers - throttle, mixture and propeller pitch (rpm) - fitted on the left side of the cockpit. The engine drives a Hamilton Standard hydromatic four-bladed 11 feet 6 inch diameter constant-speed metal propeller through a reduction gearbox. The propeller rotates in a clockwise direction when viewed from the cockpit.

The flying controls consist of pushrods, cables and pulleys actuating conventional ailerons, rudder and elevator. The aircraft is also fitted with a mechanical trim system for all three axes. Control inputs are made using a joystick and reach-adjustable rudder pedals.

The aircraft has inboard trailing edge flaps, controlled by a six-position flap handle on the left side of the cockpit. The full down position is marked 50° with other markings at 10° increments until the full up position is reached. The 20° setting is marked TAKE OFF.

The pilot’s seat is of metal construction and can be adjusted vertically to suit the occupant. The seat is designed to accommodate a parachute as the seat cushion and a kapok filled seat back cushion may be used as a life preserver. Shoulder straps and lap belt are attached to the seat and secured in a quick release safety fastener.

The type of passenger seat fitted to G-MSTG is of a very simple design with a leather covered seat and back rest fitted with a four-point harness. The seat position is not adjustable.

The cockpit is enclosed and covered by a clear Perspex sliding tear-drop canopy which extends over both the pilot and passenger. The aircraft can be flown with the canopy partially open.

Fuel is carried in integral self-sealing tanks within the inboard section of each wing. There is the facility to carry additional tanks on the underwing pylons. These tanks were not fitted on G-MSTG. The integral tank useable fuel capacity is 90 US (76.5 imp) gallons.

The cockpit instruments and controls were in their original configuration although the owner had fitted a modern transponder and GPS navigation system.

Aircraft examination

The aircraft wreckage was recovered to the AAIB for detailed examination. The cockpit instruments and switches were undamaged and, except for the battery and generator switches which had been switched to the OFF position at the accident site, were in the same configuration as they were at the time of the accident. All the instruments had decayed to their null or neutral readings when power had been switched off and produced no useful information to the investigation. Switches and levers controlling fuel, engine and landing gear were also as they had been during the accident.

The damage to the left wing, tailplane, engine bay and underside of the fuselage around the radiator scoop resulting from the impact with the tree and subsequent collision with the ground was severe, but localised. The left aileron control cables were severed at the wing root but the pulleys, levers and bellcranks up and downstream of the damage were intact. Despite this, the trim and control systems for all three axes (pitch, roll and yaw) could be examined and full range and control continuity could be demonstrated in all cases.

The fuel supply system was also badly damaged, particularly in the engine bay and the left wing tank. However, with the fuel valve and selectors as they were found, unrestricted fuel flow to the carburettor could be demonstrated. No fuel was present in the system as it had drained away through various breaches in the pipework.

The right main landing gear was down and locked but the left main gear was fully retracted within the separated wing. However, the left gear hydraulic extend and retract ram assembly had completely detached during impact with the tree and was found at the base of the tree. This allowed the left main gear to pivot freely into its retracted position in the upside down wing due to gravity.

The engine had to be removed at the accident site in order to stabilise the wreckage. Closer examination found severe distortion and fracture of the engine bearers and large cracks in the supercharger casing. The carburettor air box had parted and the throttle and mixture control linkages were severely disrupted. The air intake duct and carburettor were free from foreign objects or blockage. The reduction gearbox casing had split open and the propeller had detached along with its drive gear and main bearing. Both magnetos were in intact and all 24 high tension leads were in place and connected, although there was minor damage to the leads in the vicinity of some of the spark plug heads. There was no evidence to suggest an engine malfunction and an examination of the plugs and exhaust stubs showed the engine to be in a good state with no evidence of excessive carbon, misfire or oil leakage from any of the cylinders.

Meteorology

The Met Office provided an aftercast of conditions at the time of the accident. It stated that visibility was good and there was no low cloud. At the AAIB's request, the report particularly focused on the wind:

> *'At 1420Z the Norwich METAR reported 330 degrees at 11KT with a variation between 290 degrees and 020 degrees in the previous 10 minutes, while the Lowestoft METAR reported 320 degrees at 12KT with a variation between 290 degrees and 010 degrees in the previous 10 minutes; both within the bounds set by their respective TAFs. However the 1450Z METARs at both sites reported gusts within the previous ten minutes, of 20KT at Norwich and 21KT at Lowestoft.*
>
> *'[this data] suggests the wider area was exposed to some gust effects at the time of the accident. These observations also show that the wind direction was varying between west to north-westerly and northerly through the time of the accident. Through the rest of the afternoon, this variation continues with a westerly extreme of 270 degrees and a north to north-easterly extreme of 020 degrees.*
>
> *'…while the prevailing winds were north-westerly at the time of the accident, there was sufficient variation between west to north-westerly and northerly winds for it to be reported in the METARs/AutoMETARs from the surrounding stations, and that there were gusts in the general area, reaching the low 20KTs at Lowestoft on the coast and Norwich, approximately 12 miles inland. Furthermore, the variation in the wind remained through the rest of the afternoon.'*

Additionally, the airfield has a small weather station which recorded data, including the average and maximum wind speed and their directions for each half-hour period. Between 1430 hrs and 1500 hrs, the average direction was north-north-westerly and the average speed, 13 kt; the maximum wind was 22 kt from the north-west which equated to a maximum crosswind component at the landing strip of approximately 18 kt.

In discussion with the pilot of G-MSTG, and other pilots familiar with the Mustang, the crosswind experienced on the day of the accident was not considered excessive for a pilot of his experience on type.

Airfield information

The private farm strip used by the aircraft owner consisted of a grass runway, orientated 10/28, 825 m long and which varied in width between 37 m at its middle and 45 m at either end. There was a low hedge running across either end of the strip. On the day of the accident the runway was firm, dry and in good condition with grass cut to approximately 6 cm in length.

For noise abatement, all circuits to the airstrip are flown to the north.

There was a windsock situated on the northern side of the strip next to some farm buildings and an aircraft hangar. The field to the south of the strip had been ploughed up to a concrete track which ran perpendicular to the runway about 500 m from the threshold of Runway 28. Beyond the track the field had been cultivated presenting a soil surface with small regular grooves approximately two to three cm in depth. Figure 9 shows an aerial view of the airfield and the surrounding area.

Figure 9
Topcroft Farm Airstrip

Recorded information

Aspects of the accident flight were recorded by radar systems, an on-board GPS unit and the witness video camera.

Radar coverage in the area did not extend to ground level in the area of the airstrip, however, radar recordings provided an overview of the flight (Figure 1).

The GPS unit recovered from the aircraft was set to log position, track and heading at 30 second intervals which was insufficient to allow analysis of dynamic events. The last recorded GPS point was recorded just before the aircraft's initial touchdown point and indicated the aircraft touched down to the left of the centre line at a speed of 99 mph.

The video was recorded from a position to the south of the runway in the vicinity of the path that crosses the runway. Audio analysis of the video recording enabled an assessment of the engine rpm (Figure 10). The analysis had to take into account the Doppler shift, due to the aircraft moving relative to the position of the video camera, to derive an accurate assessment of the propeller rotational speed[1].

The Doppler shift itself, assuming steady ground speed and engine speed, indicated that the aircraft passed the camera position with a speed of between 74 and 83 mph.

The audio signatures from the propeller were analysed and calculations indicated an engine speed of approximately 2,300 rpm just prior to initial touchdown. The audio signatures at this point were not prominent, indicating the engine was at low power. Just after the second touchdown, the signatures became prominent again indicating increased engine power and increasing engine speed. The engine speed was calculated to be approximately 2,800 rpm as the aircraft passed the camera, assuming the engine speed and ground speed were approximately constant as it passed. Six seconds before impact with the tree, the propeller speed rose again reaching a maximum after 1.5 seconds and then steadily reducing until the point of impact.

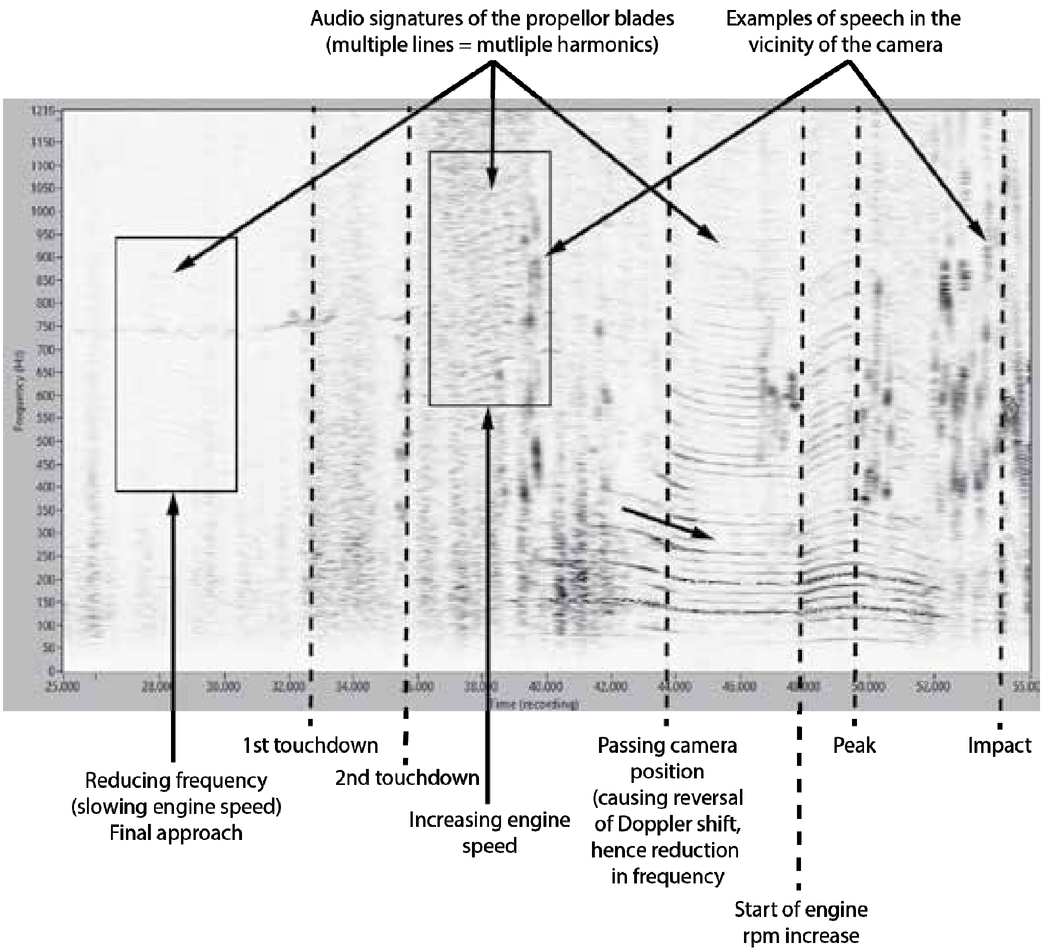

Figure 10

Spectrum Analysis of video audio

Footnote

1 Doppler shift is the apparent shift in frequency of a sound if the source is moving towards or away from the listener. An example of this is the apparent drop in tone of sirens on emergency vehicles as they change from coming towards you to going away from you when they pass.

Pilot information

The pilot obtained a PPL (A) in May 1989, which was current with a valid single engine piston (SEP) endorsement and a Class II medical certificate at the time of the accident. He had been flying historic aircraft for a number of years, including flying at air displays.

The pilot owned G-MSTG and ran a small private 'living' aircraft museum based at Topcroft Farm Airstrip, near to the old WWII Hardwick Airfield. The museum consisted of several other historic aircraft including, until recently, another P51D Mustang which the pilot had also owned. Both Mustangs had been restored and maintained through an engineering company owned by the pilot. The company was approved by the CAA in accordance with BCAR Section A, Sub-section A8.

The pilot had no recollection of the accident. He was however able to describe his usual technique for landing the aircraft and going around.

He would normally land with full flap selected and would not consider it necessary to reduce the degree of flap selected if landing in a strong crosswind. He would also open the canopy during the approach to facilitate evacuation from the aircraft in case an emergency egress was required.

Survival information

Both the pilot and passenger had remained securely strapped in their seats during the accident.

Pilot

The pilot survived the impact but suffered a number of serious injuries, particularly to his neck and burns to his face and neck. He had been wearing cotton overalls over a polyester cotton shirt. He had also been wearing a composite flying helmet with integrated headphones, microphone and visor. A small amount of soil had become trapped under the helmet visor, which was found in the up position, and there were signs of light sooting on the outer surface of the helmet.

The pilot has no recollection of the flight.

Passenger

The passenger was fatally injured with significant injuries to his head and neck. He had been wearing normal clothing and although he was wearing a headset, he had not been wearing a helmet or any other form of head protection. Medical assessment of the injuries sustained was that it was unlikely that the wearing of a helmet would have changed the outcome.

CAA guidance

The CAA offers guidance regarding clothing suitable and recommended for flying high performance ex-military aircraft in CAP 632, Flying Clothing, Chapter 7 Paragraph 17, 18 and 19, and Appendix E. The salient points are:

> *'7.17 The CAA requires that all occupants flying jet aircraft shall wear protective helmets equipped with suitable visors. For occupants of other aircraft, such helmets are considered to be highly desirable.*
>
> *7.18 The pilots, crew and any passengers flying in ex-military aircraft should, in addition to wearing a suitable helmet equipped with visor, wear a fire-retardant flying suit, leather gloves and suitable boots. When flying in coastal areas a life jacket capable of withstanding aircraft abandonment should be worn. This should be capable of being inflated during a parachute descent. The wearing of an immersion suit and carriage of a life-raft is recommended in the appropriate circumstances.*
>
> *7.19 Further guidance regarding appropriate flying clothing is given at Appendix E.*
>
> ***Appendix E***
>
> *Guidance on appropriate flying clothing and safety equipment (dress to survive)*
>
> ***Flying clothing***
>
> *E1 Use of the correct flying clothing is an important factor in the safe operation of ex-military aircraft. This class of aircraft, even the older piston engine types, are capable of operating at speeds and heights well in excess of the average light aircraft and in-service experience has led to the development of specifically designed flying clothing. Military aircrew are equipped and trained to survive accidents and incidents: civilian operators of ex-military aircraft are strongly encouraged, and in certain circumstances, required, to follow the survival best practice developed by the services.*
>
> ***Flying suits***
>
> *E2 Flying suits are the only practical garment for flying in ex-military aircraft. In addition to protection, they also assist with the storage of maps and documents and prevent loose articles falling into the cockpit, particularly important in aircraft without cockpit floors or storage areas, such as the Spitfire, the Corsair or even the Harvard.*
>
> *E3 Flying suits offer protection in the case of abandonment or ejection and, if properly fireproofed, in the case of fire. Given the possible close proximity between fuel and the pilot, particularly in piston engine ex-military aircraft, wearing of a fire resistant flying suit such as those made of Nomex is very desirable and highly recommended.*

Flying boots

E4 The use of correctly sized boots specifically designed to give good ankle support is particularly important in the abandonment or ejection scenario. Good ankle support is very beneficial in a parachute landing and it is important that, in the case of an ejection, the boots are not lost on ejection.

Flying helmets

E5 Flying helmets are required for flying in all jet aircraft and highly recommended for all other ex-military aircraft.

E6 The helmet clearly offers protection during abandonment, ejection and the subsequent parachute landing. However, it also has an important head protection role during a forced landing and, with an adequate visor in the down position, in the event of a bird strike. Given the speeds of ex-military aircraft, even when limited to 250 knots, a bird strike in the cockpit area can, and has in the past, caused pilot incapacitation.

Flying gloves

E7 Cape leather or USAF style flying gloves offer considerable protection against cockpit fires and should be worn for all flights.'

Passenger flying regulations

The CAA has in place a number of regulations and issued guidance as to the conduct of passengers flying in historic Annex II aircraft which are being flown under a permit to fly. It sets out the airworthiness compromises made in order to enable historic aircraft to fly and requires these to be brought to the attention of passenger(s).

Information provided by the passenger's family suggest that the flight was being conducted on a cost-sharing basis.

Factors potentially affecting directional control

Torque roll

The P51D has a fast responding engine mounted on the aircraft centreline giving large torque in relation to the aircraft weight. This makes the aircraft liable to torque roll, an effect where should the throttle be opened quickly it causes the aircraft to roll in the opposite direction to the propeller rotation. On G-MSTG, this would result in a roll to the left. An aircraft is particularly susceptible to this during a go-around from an approach when power is increased from, or close to, flight idle and the aircraft is less controllable due to its low speed.

The USAAF P51D Flight Handbook warns not to 'jam' the throttle forward as 'torque will cause loss of control.' The handbook reiterates this in the go-around advice stating that the throttle should be opened smoothly.

Corkscrew effect

This is the name given to the effect of the propeller slipstream which spirals around the aircraft fuselage. At low airspeeds and high propeller rpm this produces compact spirals which can exert a strong sideways force on the aircraft's vertical tail surface. On G-MSTG, due to the direction of its propeller's rotation, this causes a yawing moment around the vertical axis to the left.

Gyroscopic action

The rotating propeller has properties similar to that of a gyro. When a force is applied to a gyro, the resultant force acts at 90° ahead of, and in the direction of, rotation. Any action on the aircraft causing the propeller to change its plane of rotation also results in a force creating a pitching moment, a yawing moment, or a combination of both depending on the point at which the force was applied.

This action is more prominent in tailwheel aircraft and most often occurs when the tail is being raised during takeoff, or a go-around. This change in pitch attitude has the same effect as applying a force to the top of the propeller's plane of rotation, creating on G-MSTG a yawing effect to the left.

Asymmetric blade effect

When an aircraft is flying at a high angle of attack, the downward moving propeller blade is more effective than the upward moving blade. On G-MSTG, this moves the centre of thrust to the right side of the propeller disc, causing a yawing moment to the left.

Landing performance

The approximate aircraft takeoff and landing weights were calculated as 8,213 lb and 7,893 lb respectively. The weight calculations relied on estimated fuel quantities (as no fuel records were kept) based on the quantity of remaining fuel found in the undamaged right wing tank.

A table in the Flight Handbook for the P51D details the landing performance figures. At a landing weight of 7,893 lb the landing distance required to clear a 50 feet obstacle is stated as 1,650 feet (503 m). With the application of the CAA Safety Sense Leaflet 7c on performance the landing distance required is increased by a factor of 1.15 due to the grass surface and an additional safety factor of 1.43. This gives a total landing distance required of 828 m.

Go-around

The USAAF P51D Flight Handbook provides the following instruction for a go-around.

1. *Open throttle smoothly; do not exceed 61 in. Hg 3,000 RPM.*
1. *Maintain wings level and nose straight.*
1. *Landing gear handle* UP.
1. *Raise flaps slowly when at least 200 feet above ground.*

The Handbook also gives instructions for a go-around from a missed approach.

> 1. *Open throttle smoothly to 45 in. Hg.*
> 2. *Maintain wings level, nose straight.*
> 3. *Landing gear up.*
> 4. *Raise flaps when at least 200 feet above ground and sufficient airspeed is reached.*

The pilot reported he had carried out a number of go-arounds in the past. This included go-arounds from Topcroft Farm Airstrip, although it had been two of three years since he had last done so. He described his technique as applying about 40 inHG, keeping the aircraft close to the ground and reducing the flap by 10° to reduce drag. As speed increased he would then continue to raise the flaps one stage at a time until at a suitable speed to climb away, at which time he would raise the gear.

Analysis

Approach and go-around

During the approach the aircraft was subject to a crosswind from the right for which the pilot did not adequately compensate. The situation was compounded by the direction of the circuit, for noise abatement, which resulted in the aircraft being on the upwind side and therefore 'blown out' of the circuit as it joined the approach. This culminated in the aircraft landing to the left of the centreline.

The landing performance stated in the Flight Handbook when factored by the safety factors prescribed in the CAA Safety Sense Leaflet 7c giving 828 m made the landing distance available at Topcroft, of 825 m, marginal.

The aircraft touched down at the appropriate speed and attitude but bounced, which further subjected the aircraft to the effects of the crosswind. This was exacerbated by the small roll to the left, despite the pilot quickly applying corrective aileron.

As a result, the aircraft moved closer to the left edge of the airstrip before bouncing again. It is highly likely that the continued left sideslip would have meant that a subsequent touchdown would have been off the grass surface, something which would have been evident to the pilot. This, together with the length of the airstrip, would have provided good cause to go around.

The application of power and associated torque, corkscrew, gyroscopic and asymmetric effects, would have further increased the tendency for the aircraft to travel to the left. The ability to compensate with roll would have been limited, as the aircraft was close to the ground and over a cultivated surface. The direction of the wind would have led to the fuselage partially blocking the wind affecting the left wing, reducing its lift.

The wheel contact marks demonstrated that the aircraft was not climbing. The go-around procedure calls for a compromise between power application and controllability. The pilot's described technique differed from that in the aircraft manual. By leaving the gear down there would be an increase in drag, however the aircraft was too close to the ground to raise it safely. Equally, there is evidence that the pilot raised the flaps during the attempted go-around by 20° in an effort to reduce drag, but this would have resulted in a reduction of lift. The situation was compounded by the gear coming into contact with the cultivated ground which would have had a significant decelerating effect. The combined result was that the aircraft struggled to accelerate and remain airborne, and it veered approximately 30º to the left of the runway direction.

Final accident sequence

The magnitude and nature of the damage to the tree shows the engine was producing high power at the point of impact.

The nature and location of the damage show that the left wing root then hit the tree causing the left wing and flap to detach. The bending and distortion to the aircraft structure around the wing root and tailplane attachment suggest the aircraft was left wing low with a roll angle of approximately 60°.

As the aircraft continued forward, the remaining right wing would have produced rapid left rolling moment at which point the nose of the aircraft dipped and continued towards the ground. The rate of pitch and roll was substantial and close proximity of the ground meant the aircraft hit the ground on the upper left side of the fuselage. The canopy detached during this impact and landed nearby along with the remains of the left self-sealing fuel tank.

The aircraft then bounced on to its nose; the damage to the propeller spinner suggest the aircraft was at a near vertical attitude whilst rotating. The propeller was still under significant power at this point but detached during this impact. The aircraft inertia and rotation then caused the aircraft to carry on tail first to finally hit the ground pointing in the opposite direction to travel. The right wing and tailplane tips dug into the ground at this point bringing the aircraft to a stop. The damage to the engine bearers is likely to have occurred as a result of the torque shock as the propeller sliced through the tree. The impact at the left wing root released the self-sealing fuel tank from its bay rupturing its structure and fuel lines. The fuel in this tank was released and ignited. The majority of fire damage occurred in the remains of the tree bough and the ruptured tank. However, burning fuel appears only to have flashed over the front position of the cockpit just before or as the canopy detached.

Survivability

Although both occupants were strapped in and the cockpit remained largely intact, they were subject to considerable forces, sufficient to result in serious neck injuries. The passenger was not wearing the appropriate clothing or helmet recommended by the CAA. The passenger's head injuries were consistent with contact with a flat surface and is likely to have been caused by hitting the inside of the canopy in the first ground impact, prior to the canopy detaching. The injuries sustained were severe but it is unlikely that the outcome would have been different had he been wearing a helmet.

Some of the flashover fire injured the pilot, although the melting damage to the outside of the canopy indicates the canopy prevented most of the fire entering the rear of the cockpit. The pilot's burns were consistent with his flying suit being open and loose around his neck whilst wearing a non-fire retardant shirt underneath.

Conclusions

The aircraft appeared to have been well maintained and in a good condition at the time of the flight. There was no evidence of any aircraft system failure or malfunction which might have contributed to the accident.

The pilot was experienced on the type and would have normally been capable of flying under the prevailing conditions. However, in this case directional control was lost during the go-around due to the handling effects of increased engine power at low speed and the crosswind from the right. This, and the inability to accelerate and climb away in the space available led to a collision with a tree during the go-around.

The crosswind during the approach and landing and the requirement to fly the circuit from the upwind side due to noise restrictions affected the positioning of the aircraft on the approach. The decision to go around, after the bounces, seemed logical and it is likely that had the aircraft been able to maintain directional control during the go-around, the pilot should have been able to accelerate and climb away.

The flight appears to have complied with the requirements for operating on a cost-sharing basis laid down in CAP 632. It is clear, however, that the suggested clothing standards, particularly for the passenger, had not been adhered to. Whilst the lack of a head protection is unlikely to have affected the outcome in this accident, it might well have made a considerable difference in a similar accident at a lower speed.