Air Accidents Investigation Branch

AAIB Bulletin 11/2017

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AAIB Special Bulletins and Interim Reports

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AAIB
Air Accidents Investigation Branch

AAIB Bulletin S3/2017 *SPECIAL*

ACCIDENT

Aircraft Type and Registration:	HPH Glasflugel 304 eS, G-GSGS
No & Type of Engines:	1 LZ Design D.O.O FES-HPH-M100 brushless electric motor
Year of Manufacture:	2016 (Serial no: 059-MS)
Location:	Parham Airfield, West Sussex
Date & Time (UTC):	10 August 2017 at 1121 hrs
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Fire damage to FES batteries and FES battery compartment
Commander's Licence:	British Gliding Association Gliding Certificate
Commander's Age:	55 years
Commander's Flying Experience:	314 hours (of which 25 were on type) Last 90 days - 9 hours Last 28 days - 7 hours
Information Source:	AAIB Field Investigation

Notification

At 1530 hrs on 10 August 2017, the Air Accidents Investigation Branch (AAIB) was notified of a battery fire occurrence involving an HPH Glasflugel 304 eS electric self-sustainer sailplane during landing at Parham Airfield, West Sussex. The occurrence was initially referred to the British Gliding Association (BGA) for investigation in accordance with an existing Memorandum of Understanding between the AAIB and the BGA for non-fatal gliding accidents. Having conducted an initial investigation, the BGA requested further assistance from the AAIB, resulting in the AAIB launching a Field Investigation on 21 August 2017.

This Special Bulletin contains facts which have been determined up to the time of issue. It is published to inform the aviation industry and the public of the general circumstances of accidents and serious incidents and should be regarded as tentative and subject to alteration or correction if additional evidence becomes available.

History of the flight

The pilot had fully charged both Front Electric Sustainer (FES) batteries on 4 August 2017, after which they were disconnected from the chargers for storage. He installed them in the glider on the morning of 10 August, with the intention of flying the glider that afternoon. He initiated the FES battery self-checking procedure before conducting a daily inspection of the glider, after which the self-checking procedure had completed with no faults indicated on the FES Control Unit (FCU). He then fitted the FES battery compartment cover and applied tape around the edges of the cover.

The pilot conducted a ground run of the FES propeller, which operated normally. He then switched the Power Switch OFF, and also turned the FCU OFF, which was contrary to his normal practice of leaving the FCU switched ON.

The pilot launched from Parham Airfield by aerotow at 1021 hrs and flew in ridge lift for a period of 38 minutes before encountering a rain shower. He decided to use the FES propulsion system and turned the Power Switch ON. He then noticed that the FCU was switched OFF, so he switched the FCU ON without moving the Power Switch position[1].

After waiting a few seconds for the FCU green LEDs to show that the FES propulsion system was available, he operated the FES motor which responded normally and operated for 4 minutes. The pilot did not recall observing any fault messages on the FCU during the motor operation.

After stopping the FES motor the pilot noticed that the propeller did not realign itself correctly against the nose of the glider. The pilot had experienced this problem previously and did not consider it to be a significant issue, so he did not attempt to realign the propeller. He switched the Power Switch OFF, leaving the FCU switched ON and continued in soaring flight for a further 1 hour 15 minutes before positioning the glider to land on grass Runway 04 at Parham Airfield. The circuit was flown normally to a smooth touchdown, however at the moment of touchdown the pilot heard an unexpected noise.

As the glider slowed during the ground run, the pilot smelled burning and the cockpit filled with smoke that was moving forwards from behind the pilot's head. The pilot did not report observing any warning messages or illuminated LEDs on the FCU, although his attention was drawn outside the cockpit during landing. He vacated the cockpit normally, without injury, and observed that the FES battery compartment cover was missing and that smoke, followed shortly by flames, was coming from the battery compartment. The airfield fire truck arrived promptly and an initial attempt was made to extinguish the fire using a CO_2 gaseous extinguisher, but this proved unsuccessful. Aqueous film-forming foam (AFFF) was then sprayed into the FES battery compartment and the fire was extinguished.

Footnote

1 The FCU User Manual and HPH304 eS Flight Manual both state that the FCU should be switched to ON at all times that the sailplane is in flight, with the Power Switch only switched ON when the pilot wishes to operate the FES propulsion system. The FES system manufacturer stated that despite this departure from approved procedures, the sequence that the FCU and Power Switch were turned ON in this event would not affect the operation of the FES propulsion system.

Figure 1
Fire in the FES battery compartment following the landing roll

The FES battery compartment cover was found close to the glider's touchdown point. The cover's rear carbon fibre catch was fractured, consistent with a vertical load acting on the inside of the cover. The cover did not exhibit any overheating damage.

Aircraft description

The HPH Glasflugel 304 S is a single-seat flapped sailplane of 18 m wingspan, constructed from composite materials with a retractable mainwheel. The 304 eS variant of the type is a powered variant, capable of self-sustaining flight using a Front Electric Sustainer (FES) propulsion system. The FES system, Figure 2, consists of the following components:

- One 23kW brushless electric motor installed in the nose of the sailplane, with a foldable two-bladed propeller
- One motor controller
- Two 'GEN2' 58V battery packs, connected in series, each with an internal Battery Management System (BMS)
- One FES control unit (FCU) instrument, mounted in the instrument panel, displaying FES system monitoring information and a motor throttle knob
- One LXUI box with a shunt, for current and voltage measurements

- One FES connecting circuit (FCC) box
- One Power Switch, to provide a 12V power supply to the battery contactor, which connects the FES battery packs to the motor controller. It also provides a 12V power supply to the motor controller
- One DC-DC converter to convert FES battery pack voltage to 12V, to power the avionics and components of the FES system requiring a 12V supply (battery contactor, cooling fans, LXUI box and FCC box)

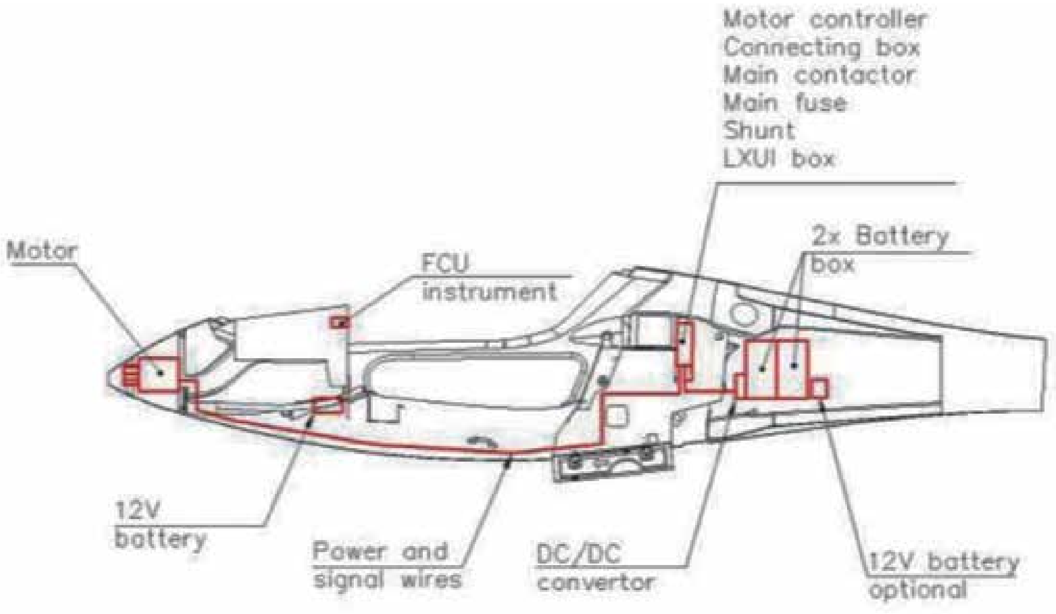

Figure 2

FES system installation in the HPH Glasflugel 304 eS powered sailplane (courtesy HPH Spol. S.r.o.)

The FES battery packs are removable for charging remotely from the sailplane. Each FES battery pack is built up from 14 Superior Lithium Polymer Battery (SLPB) cells, connected in series and contained within a carbon fibre battery box with a machined aluminium alloy cover plate/heatsink. The maximum total voltage for each battery pack is 58.3V, giving a maximum voltage of 116.6V for the assembly of both battery packs connected in series. The capacity of each SLPB cell is 41 Ampere-hours (Ah), providing a total capacity for each FES battery pack of 2.1 kWh, or 4.2 kWh for both battery packs connected together. Each FES battery pack has a mass of 15.7 kg.

The HPH Glasflugel 304 eS powered sailplane has a European Aviation Safety Agency (EASA) Restricted Type Certificate (RTC), number EASA.A.030. The sailplane does not have an unrestricted Type Certificate as the FES engine and propeller are not EASA Type Certified in their own right, and are therefore considered part of the sailplane for certification[1] purposes. There are no operational restrictions related to the RTC.

Footnote

[1] EASA Part 21.A.23 (c)(2).

The FES propulsion system is also installed in two other powered sailplanes that hold EASA RTCs – the Schempp-Hirth Flugzeugbau Discus-2c FES (EASA.A.050) and the Sportline Aviacija LAK-17B FES (EASA.A.083). In addition, there are a number of other powered sailplanes equipped with the FES propulsion system currently operating on EASA Permits to Fly, that are part-way through the EASA Type Certification process.

The FES propulsion system is also installed in two commercially-available 'EASA Annex II' microlights – the Alisport Silent 2 Electro, and the Albastar AS13.5m FES. These 'EASA Annex II' aircraft are not subject to EASA airworthiness regulations and may operate in the UK under the Single-Seat Deregulation (SSDR) airworthiness exemption from the Air Navigation Order (ANO).

The AAIB is also aware of a number of other FES-equipped EASA Annex II microlights, produced as modifications to existing sailplane designs that are currently in operation. These include two Pipistrel Apis 15M M FES sailplanes operating in the UK under SSDR regulations and one Diana 2 Versvs FES sailplane operating in Italy on an ENAC Permit to Fly. In addition one FES-ASW-27 operates in the USA under FAA Experimental Category regulations.

FCU description

The FCU is an instrument installed in the instrument panel that informs the pilot of the status of the FES propulsion system via a display screen, Figure 3. A rotary throttle knob is provided at the bottom of the FCU that controls the power delivered to the propeller during powered flight. The rotary knob may also be pushed to confirm warning messages displayed on the FCU screen.

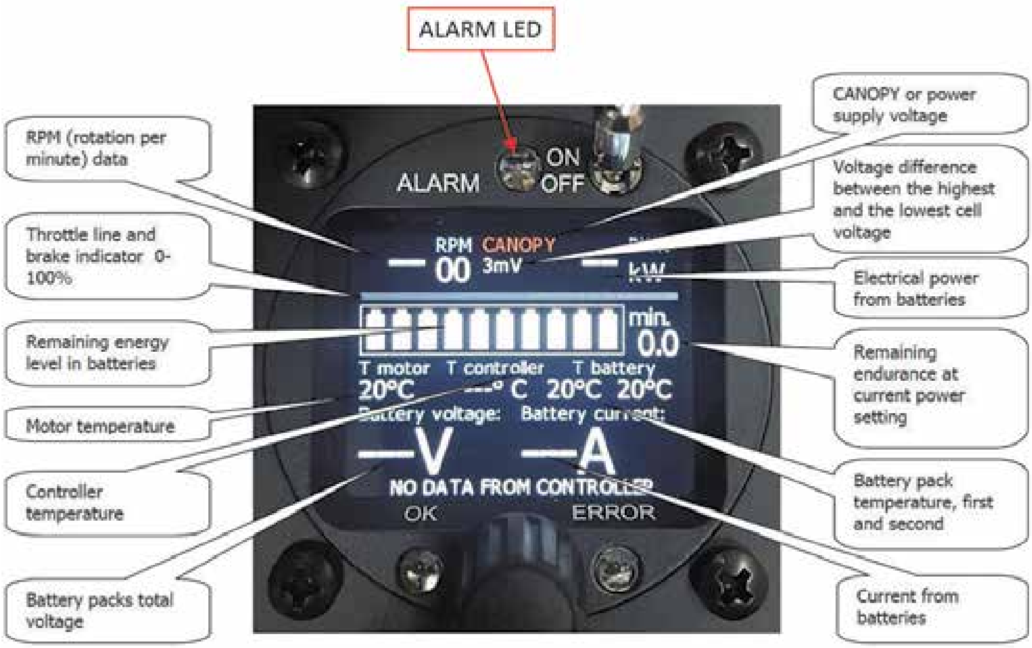

Figure 3

FCU main screen (courtesy LZ design d.o.o.)

Coloured LEDs on the FCU instrument bezel are used to confirm the FES system status and alert the pilot of system warning messages. Two levels of warnings are provided:

- YELLOW warning: This is first level of warning, which means that the pilot needs to be aware of the parameter indicated in the warning message and to manage the suggested solution to solve the problem. YELLOW warnings indicate that there is no immediate danger. The top 'ALARM' LED appears as continuous red light. The LED and warning message on screen are confirmed by pressing the throttle knob.
- RED warning: This is second level of alarm which means that the pilot has to manage the solution of the indicated problem immediately. The top 'ALARM' LED appears as a flashing red light. The warning message on the screen is confirmed by pressing the throttle knob, but the flashing top LED persists whilst the fault condition is present. Red warning messages may be recalled by pressing the throttle knob.

In a fault scenario where multiple warning messages are generated, the pilot is not aware of how many messages are present until all have been confirmed by pressing the throttle knob. Warning messages are displayed in the order they were generated and red messages, including the change in the ALARM LED indication from a steady red to a flashing red illumination, are not prioritised over yellow warning messages.

The FCU does not currently record any data or fault messages and therefore it is not known which messages were displayed to the pilot of G-GSGS during the battery fire event. The FES system designer confirmed however that, for the configuration G-GSGS was in when the event occurred (Power Switch OFF, propeller not rotating), the following warning messages may have been generated (Table 1).

Warning level	FCU screen warning message	ALARM LED	Required pilot action
YELLOW	Battery diff. >3°C, Reduce power!	Steady red, cancellable	Reduce power
RED	Battery diff. >6°C, Stop FES motor!	Flashes red, persistent	Stop FES motor
RED	Batt. Critical >75°C, Land immediately!	Flashes red, persistent	Stop FES motor and land ASAP

Table 1

Possible FCU warning messages during the G-GSGS FES battery fire event

The first two warnings are generated when the FCU senses a temperature difference between the two FES battery packs. The third warning occurs when the temperature of either FES battery pack exceeds 75°C. Each message is reliant on data sent from a functioning BMS of a FES battery pack. Apart from alerting the pilot to a battery pack temperature exceeding 75°C, the FCU does not provide any indication of a fire occurring in the FES battery compartment. As the FES battery compartment is behind the pilot within the fuselage, a pilot cannot see such a fire if it occurs. The warning messages may also be confusing to the pilot as the required pilot action refers to reducing or stopping the FES motor, when the motor is not in operation.

Aircraft damage

The origin of the fire was the forward FES battery; its battery box was ruptured along the rear left corner and the battery assembly was heavily fire damaged, Figure 4. The rear FES battery box suffered from external fire damage although the internal components were only slightly damaged and the cells remained charged.

Figure 4
Fire damage to the forward FES battery

The FES battery compartment was heavily fire damaged with burning of the composite material's resin on the internal faces of the battery compartment and around the external cut-out in the upper fuselage skin. The top edge of the removable access panel that forms the front panel of the battery compartment (Figure 5) was also burned on its forward face and the FES electrical components in the equipment bay between the cockpit and the FES battery compartment were covered in soot deposits, demonstrating that the battery compartment had not contained all of the smoke and fumes released by the FES battery fire.

Figure 5

Fire damage to the FES battery compartment
front access panel (left image, looking forwards),
and to the forward face of the front access panel (right image, looking aft)

The electrical cable glands in the left side of the front bulkhead of the battery compartment remained intact. The main 325A power fuse was intact, as were fuses on the instrument panel. The DC-DC converter, installed in the battery compartment forward of the FES batteries, was externally fire damaged but when inspected it was apparent that the damage had been caused by external heating of the DC-DC converter during the fire. No evidence of overheating or fire damage internally within the DC-DC converter case was observed.

Other information

The pilot reported that in January 2017 one of the FES battery packs from G-GSGS fell from his car onto a paved surface through a vertical distance of around 0.2 m. There was no sign of damage to the battery pack following this event. The pilot did not record the serial number of this battery pack and therefore it is not possible to determine whether this pack was the battery that caught fire during the landing at Parham Airfield.

Second FES battery fire event

The AAIB is aware of a second FES battery fire event that occurred at Benesov Airport in the Czech Republic on 27 May 2017. The FES-equipped powered sailplane was de-rigged for storage in its trailer, with both FES battery packs installed and connected together in the sailplane. This was contrary to an instruction in the sailplane's Flight Manual, which required the connecting cables between the FES battery packs to be removed after landing. The FES battery packs remained charged to approximately 80% capacity after the flight that day. The FES Power Switch was OFF, as were the avionics master switch and FCU switch. The fire occurred in the forward FES battery pack, causing significant damage to the battery compartment. The pilot of this sailplane had reported running over a "hard bump" during the latter stages of the landing roll, but apart from this the flight was unremarkable and no signs of heat emission were present when the sailplane was de-rigged and placed in the trailer after the flight.

EASA Emergency Airworthiness Directive EAD 2017-0167-E

As a result of the two FES battery pack fire events, on 6 September 2017 EASA issued Emergency Airworthiness Directive (EAD) 2017-0167-E, applicable to three powered sailplanes types holding EASA RTCs (HPH 304 eS, Discus-2c FES and LAK-17B FES). The EAD requires that:

> *'Modification:*
>
> *(1) Before next flight after the effective date of this AD, modify the FES battery pack or its installation, as applicable, in accordance with instructions approved by EASA, or by the applicable design approval holder.*
>
> *(2) Removal of the FES battery pack from a powered sailplane is an acceptable alternative method to comply with the requirements of paragraph (1) of this AD, provided flights without an installed FES battery pack are allowed for that powered sailplane.'*

At the publication date of this AAIB Special Bulletin, no modification as mentioned in part (1) of EAD 2017-0167-E is currently available.

FES battery compartment warning systems

As a result of the AAIB investigation to date, the AAIB remains concerned that existing FES battery installations do not provide sufficient warning to a pilot of a fire or other hazardous condition (such as high pressure) occurring within the FES battery compartment. As the G-GSGS fire event has demonstrated, a severe battery fire may occur rapidly and as the FES battery compartment is behind the pilot, within the fuselage, such a fire may not be seen by the pilot. The FES batteries provide an energetic fuel source for a fire and once started, the pilot has no means by which to suppress or remove the fuel source from the fire. The timely and unequivocal warning of a FES battery fire or other hazardous condition is required, to allow the pilot to decide which mitigating actions to take, such as landing the aircraft immediately or abandoning the aircraft by parachute.

The following Safety Recommendation is therefore made:

Safety Recommendation 2017-018

It is recommended that the European Aviation Safety Agency (EASA) requires that all powered sailplanes, operating under either an EASA Restricted Type Certificate, or an EASA Permit to Fly, and fitted with a Front Electric Sustainer (FES) system, are equipped with a warning system to alert the pilot to the presence of a fire or other hazardous condition in the FES battery compartment.

Further, to cover the two commercially-available FES-equipped aircraft types outside EASA airworthiness regulation, the following Safety Recommendations are made:

Safety Recommendation 2017-019

It is recommended that Alisport Srl modifies the Silent 2 Electro microlight to incorporate a warning system to alert the pilot to the presence of a fire or other hazardous condition in the Front Electric Sustainer (FES) battery compartment.

Safety Recommendation 2017-020

It is recommended that Albastar d.o.o. modifies the AS13.5m Front Electric Sustainer (FES) microlight to incorporate a warning system to alert the pilot to the presence of a fire or other hazardous condition in the FES battery compartment.

Investigation plan

The AAIB investigation continues, including detailed examination of the fire-damaged forward FES battery pack from G-GSGS intended to identify, if possible, the origin of the failure within the battery pack. It is also planned to examine additional FES battery packs using CT X-ray inspection techniques to determine whether any internal anomalies are present in those battery packs. The scope of the AAIB investigation also includes a review of the certification processes followed by EASA in the approval of those powered sailplanes in receipt of EASA RTCs.

Published 25 September 2017

AAIB Field Investigation Reports

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

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

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

ACCIDENT

Aircraft Type and Registration:	Boeing 737-4Q8, OE-IAG
No & Type of Engines:	2 CFM56-3C1 turbofan engines
Year of Manufacture:	1992 (s/n 25168)
Date & Time (UTC):	4 October 2016 at 0455 hrs
Location:	Runway 25, Belfast International (Aldergrove) Airport
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Fractured lower torsion link on right main gear leg
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	5,900 hours (of which 900 were on type) Last 90 days - n/k hours Last 28 days - n/k hours
Information Source:	AAIB Field Investigation

Synopsis

On landing, an intense vibration developed, the crew cancelled the automatic brakes and thrust reversers, as there was sufficient runway, and the aircraft came to a stop. The lower torsion link was found to have fractured on the right main landing gear (MLG) possibly due to excessive MLG vibration (shimmy). The cause of the vibration could not be established but may have been related to the speed of the aircraft on landing, and possibly a problem with the shimmy damper or freeplay within the joints associated with the upper and lower torsion links.

History of the flight

The aircraft had taken off from East Midlands Airport carrying 16 tonnes of cargo. It landed at Belfast International Airport at a weight of 54,900 kg (98% of the maximum landing weight) with a forward, but within-limits, centre of gravity. At the time of the landing there was a tailwind component of 5 kt and a crosswind component of 10 kt from the left.

The aircraft touched down about 250 m beyond the threshold of Runway 25. The crew did not recall anything unusual about the touchdown. The speedbrakes were deployed, and subsequently the thrust reversers and the brakes were selected. The crew felt a vibration that started to increase in intensity and they suspected a tyre failure. The anti-skid fail warning illuminated, and the crew cancelled the thrust reversers and automatic braking as sufficient runway remained in which to stop. The aircraft track continued to oscillate close to the runway centreline before stopping 2,170 m beyond the threshold of Runway 25 at its intersection with Runway 17/35. There were no injuries and the aircraft was moved from the runway at approximately 1800 hrs.

Aerodrome information

Belfast International Airport, also known as Aldergrove, has two intersecting runways: Runway 07/25, 2,780 m long and Runway 17/35, 1,891 m long (Figure 1).

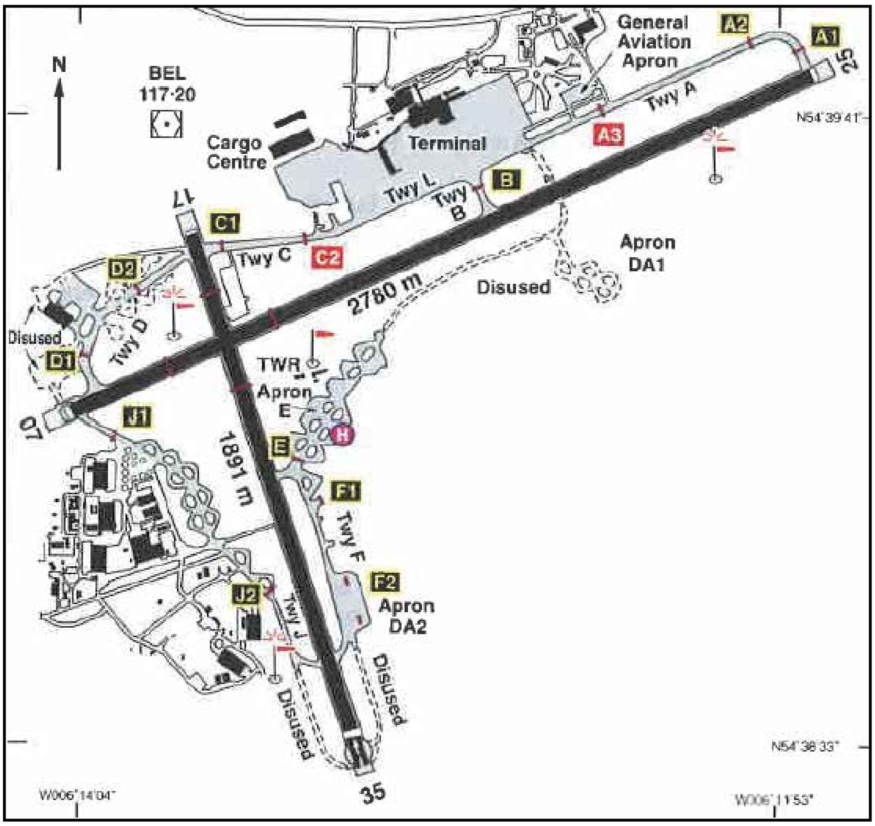

Figure 1

Plan of Belfast International Airport (courtesy of Pooleys)

Meteorological information

The METARs at Belfast International Airport around the time of the accident were:

EGAA, Belfast / Aldergrove Airport (United Kingdom)
Latitude 54-39N. Longitude 006-13W. Altitude 81 m.

201610040420 METAR EGAA 040420Z 13011KT 090V150 CAVOK 12/09 Q1026=
201610040450 METAR EGAA 040450Z 13009KT CAVOK 12/09 Q1027=
201610040520 METAR EGAA 040520Z NIL=
201610040550 METAR EGAA 040550Z 13009KT 090V150 9999 FEW010 12/09 Q1027=

A surface wind of 130° at between 9 and 11 kt equates to a tailwind component of around 5 kt and a crosswind component of about 10 kt from the left for Runway 25.

The Met Office commented that:

> *'If the 2000FT wind is assumed to have been a conservative 35 KT the vertical wind shear was 12KT/1000FT which meets the requirements for severe turbulence.'*

The aircraft manufacturer calculated a tailwind component of 5 kt from 1,000 ft agl to touchdown and a crosswind of 30 kt from the left at 1,000 ft, dropping to about 10 kt from the left at touchdown.

On-site investigation

The aircraft stopped on Runway 25 at its intersection with Runway 17/35 (Figure 2).

Figure 2

Image showing aircraft stopped at intersection of the two runways

A pair of parallel tyre marks to the right of the centre line on Runway 25 had a distinctive 'S-shaped' pattern, and started approximately 900 m from the threshold of Runway 25. They continued to the main wheels on the right MLG leg; however for the last 60 m the two marks became straight (Figures 2, 3 and 4).

Figure 3

Image showing tyre marks close to the aircraft

Figure 4

Image looking approximately east showing tyre marks

When inspected, both wheels of the right MLG were skewed to one side and there was significant damage to both wheel hubs and both tyres (Figure 5). Both tyres had remained inflated.

The lower torsion link on the right MLG had fractured. Several pieces of debris were recovered from the runway, including pieces of the bushings from the apex where the upper and lower torsion links join. It was not possible to make an accurate assessment of the shimmy damper link condition due to the high level of damage.

Figure 5
Image of right MLG showing torsion link

Recorded information

The aircraft's flight data recorder (FDR) and cockpit voice recorder (CVR) were downloaded and their recorded data analysed.

Descent into Belfast International Airport

The FDR data showed that as the aircraft descended through 1,000 ft it was configured with flaps 30, and autopilot and auto throttle disengaged. The calibrated airspeed was about 148 kt (V_{REF} + 7), with a tailwind component of approximately 5 kt and crosswind component of approximately 30 kt from the left.

As the aircraft descended below 500 ft, the descent rate was a nominal 800 fpm. This was maintained until about 40 ft agl when the landing flare was initiated, reducing to about 600 fpm (10 fps) at touchdown. The aircraft touched down with 1.7° of left bank and a drift angle of 3° to the right, at about 148 kt CAS (V_{REF} + 7) and a peak recorded normal acceleration of 1.65 g.

Ground track

Figure 6 shows the pertinent data for OE-IAG during the landing rollout and the resulting ground track. The distance on the x-axis (CALCULATED DISTANCE FROM RUNWAY THRESHOLD) is based on an integration of the groundspeed, then working back along Runway 25 from the crossing with Runway 17/35 where the aircraft came to a stop and runway information published in the UK Integrated Aeronautical Information Package. The lateral distance of the aircraft from the runway centreline (CALCULATED LATERAL DEVIATION FROM RUNWAY CENTRELINE) is based on localiser deviation.

An analysis of the data indicates that the aircraft touched down about 250 metres beyond the threshold to Runway 25. The speed brakes deployed on touchdown and the thrust reversers were fully deployed by 530 m beyond the threshold. At about 690 m beyond the threshold, the air/ground discrete erroneously changed to AIR, followed by oscillations in lateral acceleration.

At 950 m beyond the threshold, the brakes were applied. They were released temporarily after about 600 m when the thrust reversers were re-stowed. The aircraft then oscillated from the runway centreline before stopping 2,170 m beyond the threshold.

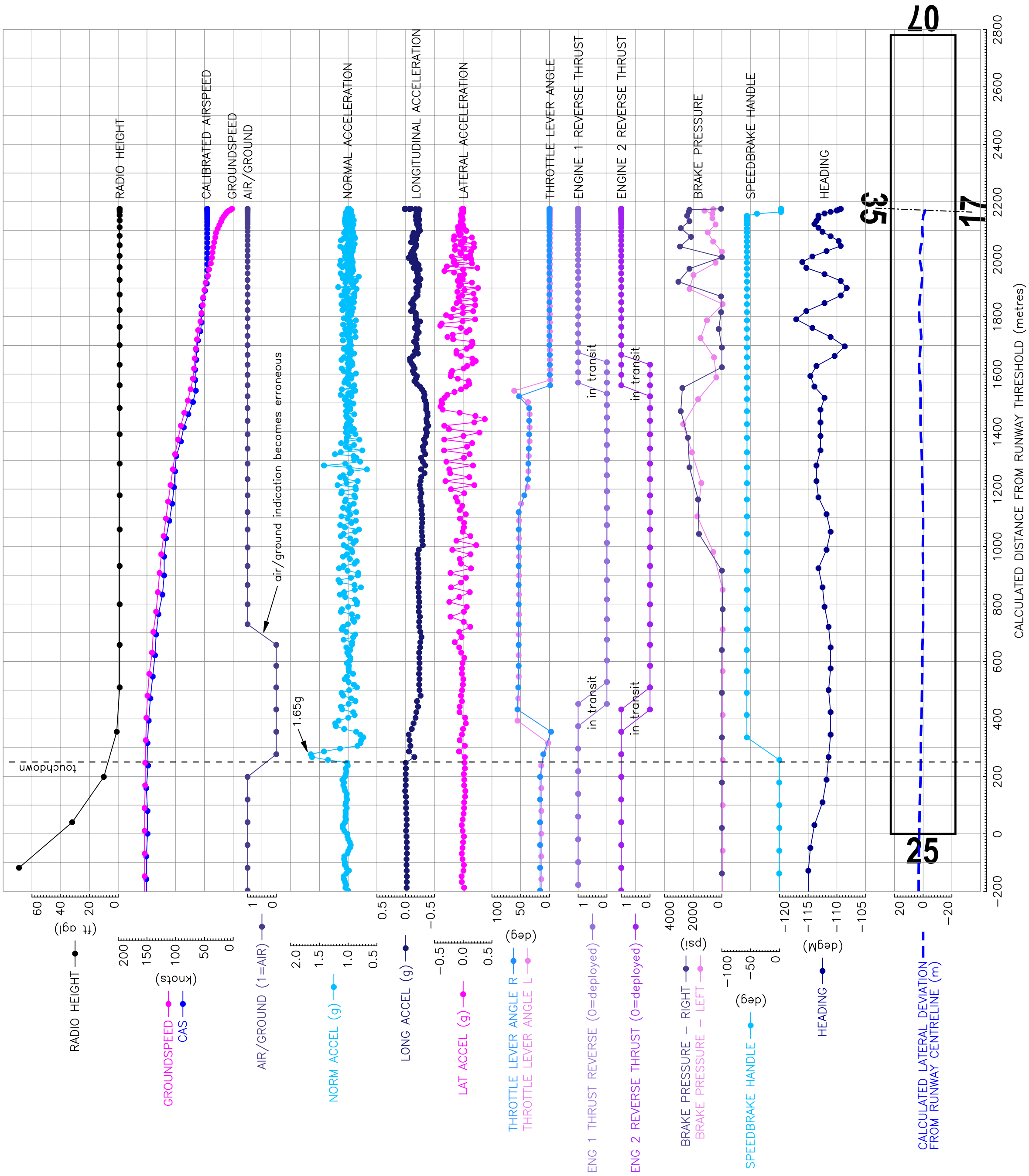

Figure 6

Pertinent FDR data and ground track on landing

Aircraft information

The Boeing 737 MLG leg consists of a cylinder/piston type shock-strut, with the outer cylinder attached to the wing structure, and the lower end of the inner piston carrying an axle with two main wheels. The axle centreline is located 9 cm behind the shock-strut centreline to provide a castoring effect.

A scissor linkage, made up of an upper and lower torsion link, is intended to prevent rotation of the inner piston relative to the outer cylinder, while allowing axial movement to provide shock absorption (Figure 7). The upper torsion link is attached to the outer cylinder via a horizontal pivot joint and the lower torsion link is similarly attached at the inner piston.

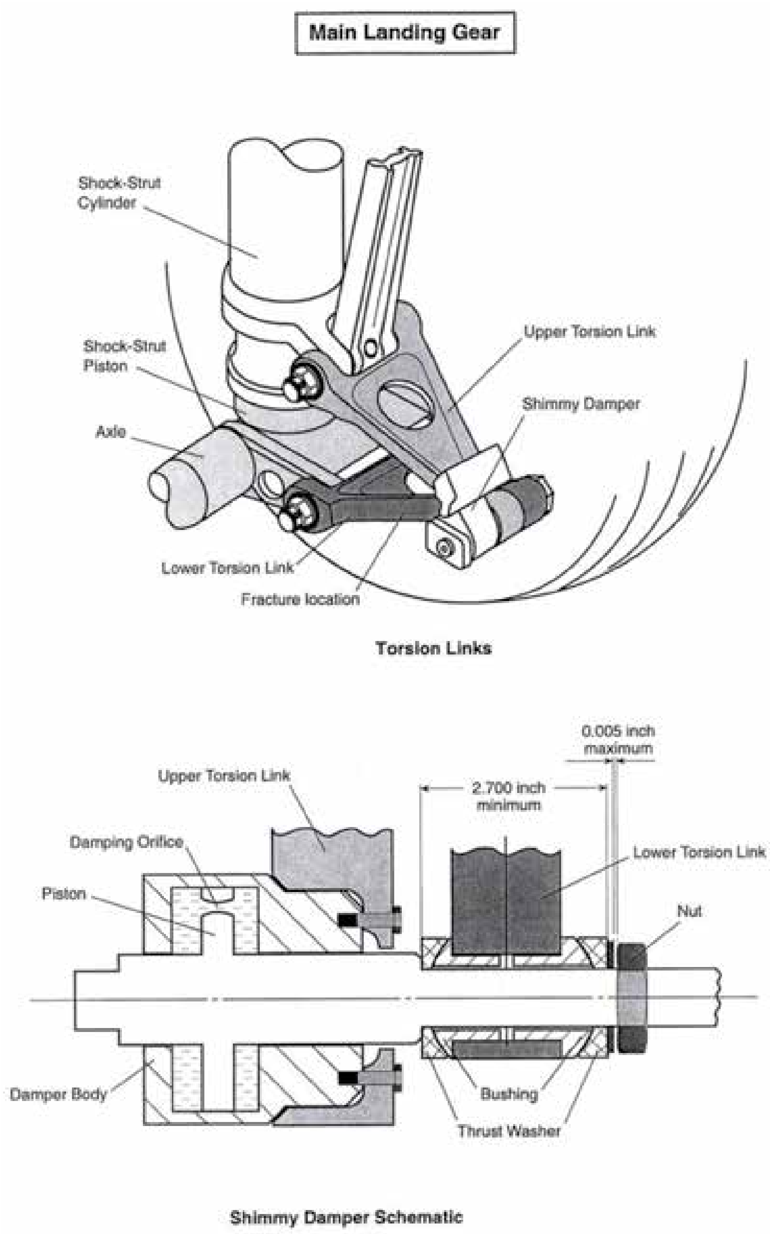

Figure 7
Schematic of MLG and shimmy damper

A shimmy damper is connected between the apexes of the upper and lower torsion links in order to control the rotary oscillation of the shock-strut inner piston relative to the outer cylinder and thereby prevent excessive MLG vibration (shimmy) during high-speed taxi and under heavy braking. The apex of the upper torsion link is bolted to the damper body and the apex of the lower torsion link is connected to the damper piston rod via a bearing assembly. This consists of spherical bushes sandwiched between two thrust washers and is clamped against a shoulder on the rod by an end nut. The torsion links can pivot relative to each other but horizontal displacement between their apexes is controlled by the damper action (Figure 7).

Previous shimmy events

The phenomenon of shimmy, which is an abnormal wheel vibration, is a known issue for the MLG on this aircraft type and typically has a frequency of approximately 15 Hz. To reduce the possibility of shimmy not being damped out due to wear in the apex joint, the applicable issue of the Aircraft Maintenance Manual specifies a number of checks and maintenance operations related to the MLG torsion links and the shimmy damper to replace worn, fractured or cracked apex bushings or apex thrust washers.

The manufacturer provided advice in a quarterly publication in 2013 entitled '*Preventing Main Landing Gear Shimmy Events*', which is applicable to the Boeing 737-100, -200, -300, -400 and -500 models:

> *'…(the manufacturer) recommends pilots strive for a landing with normal sink rates with particular emphasis on ensuring that the auto speedbrakes are armed and deploy promptly on touchdown. An overly soft landing, or a landing which the speedbrakes do not deploy promptly, allows the landing gears to remain in the air mode longer, which makes them more vulnerable to shimmy. This is especially true when landing at airports at higher elevations, where the touchdown speed is increased.'*

Later variants of Boeing 737 have a different design and are less susceptible to shimmy.

The manufacturer has also published the following information for the 737 fleet:

- Multi Operator Message MOM-MOM-15-0853, Boeing participation in 737CL Main Landing Gear collapse events under investigation on 15 December 2015
- Service Letter 737-SL-32-057E, Main Landing Gear Lower Torsion Link Fractures on 22 December 2015
- Fleet Team Digest Article 737-FTD-32-11001, Main Landing Gear Shimmy on 15 December 2015.
- Flight Operations Technical Bulletin 737-15-2, Main Landing Gear Shimmy on 14 December 2015.

Assessment of the wear in the bushings

The torsion link exhibited some evidence of wear in the bushings. However, the manufacturer, having compared the wear with bushings which had been causal in previous events, did not consider that the wear in the bushings on OE-IAG was significant.

Assessment of fractured torsion link

The two pieces of the fractured lower torsion link (Figure 8) were sent to a metallurgical laboratory for an assessment of the fracture surfaces (note the inboard lug at the top left of the image was cut during removal from the aircraft).

The assessment concluded that the torsion link had failed in overload. There was no evidence of fatigue. It was concluded that the failure of the torsion link was caused by shimmy.

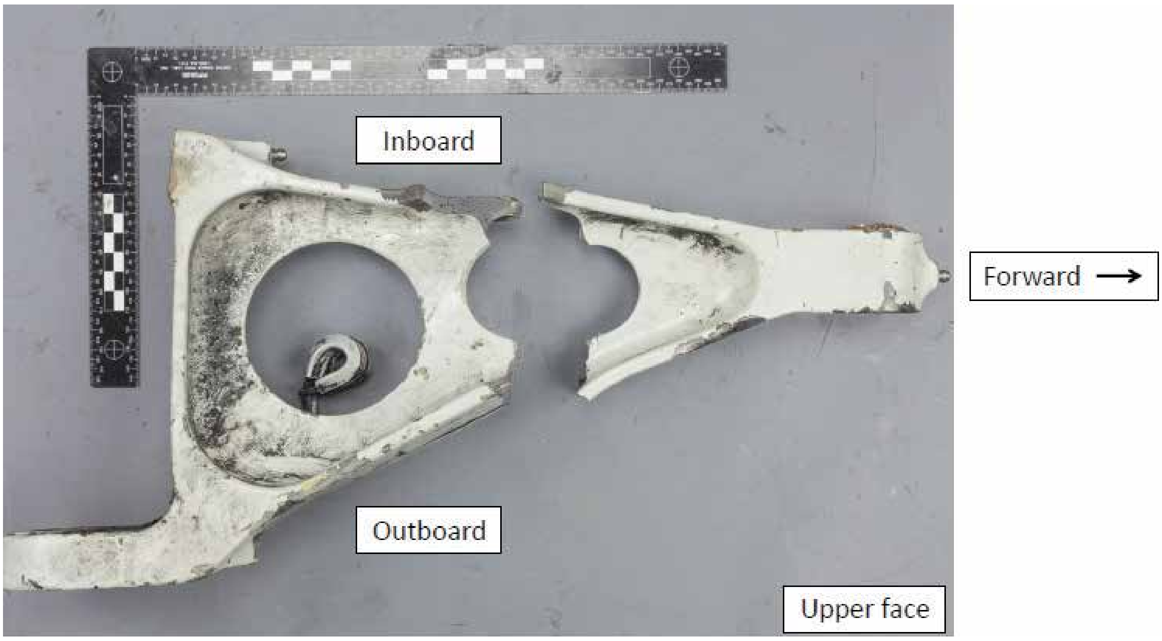

Figure 8

Image of fractured torsion link (courtesy of QinetiQ)

Aircraft maintenance records

Maintenance records indicated that the torsional free play check between the inner and outer cylinder, and therefore an indication of wear at the torsion link apex, had last been successfully carried out on the right MLG in January 2015, with a visual check of the torsion links for security and damage in November 2015; nothing significant was found.

Manufacturer's analysis of FDR data

The manufacturer noted that high-speed landings have been shown to elevate the risk of landing gear shimmy. It noted that the:

> *'Flight Crew Reference Manual[1] recommends an approach with a tailwind be flown at Vref+5, with the 5 knot additive being bled off during flare. In this case, the airplane touched down at a computed airspeed of 148 kt (Vref+7). In addition the tailwind increased the groundspeed at touchdown to 153 knots'*

Analysis

The physical and recorded evidence indicate that the fracture to the lower torsion link on the right MLG leg was most likely caused by shimmy. This and previous occurrences show that the Boeing 737 MLG is susceptible to shimmy, particularly at higher landing speeds and for softer landings.

The manufacturer has a mature and well-documented list of probable causal factors for shimmy on this aircraft type. There was no evidence of a pre-existing defect in the failed torsion link or the apex joint which would have caused the shimmy. It was not possible to assess the condition of the shimmy damper or determine if there was any freeplay in the joints associated with the torsion links. Accordingly it is possible that there was a failure of the damper or excessive freeplay in the joints, which combined with the high-speed landing may have induced shimmy.

Whilst there was no evidence to suggest that maintenance was a causal or contributory factor, the manufacturer is currently working with the operator to assess the maintenance requirements to ensure they are appropriate for its operations.

Footnote

[1] 737 Classic Flight Crew Training Manual (FCTM) The Boeing Company, Revision date June 30, 2016

ACCIDENT

Aircraft Type and Registration:	Europa, G-NDOL
No & Type of Engines:	1 Rotax 912ULS engine
Year of Manufacture:	1995 (Serial no: PFA 247-12594)
Date & Time (UTC):	28 May 2017 at 1200 hrs
Location:	Apperknowle, Derbyshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Light Aircraft Pilot's Licence
Commander's Age:	79 years
Commander's Flying Experience:	1,146 hours (of which 880 were on type) Last 90 days - 7 hours Last 28 days - 1 hour
Information Source:	AAIB Field investigation

Synopsis

The aircraft took off from Coal Aston Airfield but did not achieve a normal rate of climb. At the end of the runway it turned to the left and then stalled, descending into an adjacent field. The pilot was possibly attempting to land back at the airfield. The evidence indicates that the engine suffered a partial loss of power, probably as a result of fuel vapour disrupting the fuel supply to the engine. It was found that the fuel vapour return line had been connected to the inlet of the fuel selector valve, rather than to the fuel tank. Any vapour in the fuel system was therefore routed back to the engine instead of returning to the fuel tank to dissipate. The accident was not survivable.

History of the flight

Background

The pilot purchased the aircraft in 2014 and kept it in a hangar at Coal Aston Airfield. In August 2016 he landed with the landing gear retracted, causing damage to the propeller. The propeller was replaced, but subsequently he again landed with the landing gear retracted. He borrowed a replacement propeller from a friend and fitted it to his aircraft.

On the day of the accident the pilot was engaged in testing a modification he had designed for the aircraft to warn of an impending landing with the landing gear retracted. Persons he spoke to at the airfield said that he was very focussed on this modification.

Previous flights

The pilot carried out two separate flights earlier in the morning before the accident flight. Grass Runway 29 was in use at Coal Aston and at 1100 hrs he took off on the first flight. He flew to the south of the airfield, flying over his house, located 5 nm to the south. He returned and landed at 1120 hrs. He commented afterwards to a friend at the airfield that he had just done an "awful" landing, the "worst ever".

A short while later he began a takeoff from Runway 29. After becoming airborne the aircraft was seen to fly above the runway at a height of about 10 ft to 15 ft before landing ahead and stopping on the runway. The reason for this short flight was not determined; it may have been related to the landing gear warning modification, but he did not discuss it with anyone.

Accident flight

At about 1156 hrs, the pilot started another takeoff from Runway 29. Witnesses alongside the runway, approximately three-quarters along its length, saw the aircraft lift off and start to climb. However, the aircraft did not appear to them to be climbing as well as they expected and it was still quite low, estimated at 100 ft to 150 ft, when it passed in front of them. As the aircraft passed by they heard the engine noise reduce; one person suggested the engine sounded as though it had reduced to about 4,000 rpm, and another that the engine was sputtering.

The witnesses saw the aircraft start a left turn at the end of the runway and continue in a left turn before descending in a steep nose-down attitude out of sight. Moments later they heard a "thud" as it struck the ground.

Other witnesses were in a house to the south of the airfield. Through a ground floor window they saw the aircraft pass across their field of view, flying very low and in a banked attitude. They then heard the sound of a crash, and immediately alerted the emergency services and ran across to the accident site.

They reached the aircraft but were unable to assist the pilot who had not survived the impact. The emergency services were at the scene within approximately 7 minutes.

Pilot information

The pilot first qualified for his licence in 1991 and had been flying for 26 years; the majority of his flight time was on Europa aircraft. He had recorded 34 hours in the 12 months prior to the accident, including a one hour flight with an instructor in September 2016. He had flown 5 hours in 2017; his most recent flight before the day of the accident was 20 April 2017.

Meteorology

The weather conditions at Coal Aston Airfield were clear with a westerly wind of approximately 10 kt, good visibility and scattered clouds. As a result of the scattered clouds, the sun was out for most of the morning. At Doncaster Sheffield Airport, 20 nm to the north-east, the temperature was recorded as 20°C at 1150 hrs.

Airfield information

Coal Aston Airfield is located on a ridge of high ground at an elevation of 720 ft amsl. The ground falls away to the west and south, limiting the options for a forced landing when taking off in a westerly direction. Grass Runway 29/11 is 610 m long and 20 m wide, and the surface is undulating with an overall downslope from east to west. At the west end of Runway 29 is an open grass area, extending for 160 m, and then a hedgerow. A minor road runs behind the hedge beyond which there are several small fields, sloping down away from the airfield.

Description of the aircraft

General

The Europa is a home-built, two-seat, side-by-side light aircraft of conventional layout and composite construction. It is sold in kit form and in the UK its construction is overseen by the Light Aircraft Association (LAA) through a network of approved inspectors. Once the aircraft has been completed to the required standard a Permit to Fly can be issued.

It is available with either tricycle landing gear, or as a mono-wheel with a single mainwheel, tailwheel and outriggers on the wings. G-NDOL was a mono-wheel version with a 'classic' wing which had stall warning strips fitted. During the most recent flight test, the stall speed in the clean configuration was recorded as 52 kt with natural buffet occurring at 55 kt; behaviour at the stall was noted as satisfactory.

Engine

This aircraft was fitted with the recommended Rotax 912ULS engine, although when originally constructed it had another engine type installed. The modification to the current engine was completed in 2002.

The Rotax 912ULS is four-cylinder, horizontally-opposed, four-stroke, piston engine producing 73.5 kW (98.5 BHP) at 5,800 rpm (Figure 1). G-NDOL, which had a fixed-pitch propeller with a recorded maximum static rpm of 5,550 rpm, would have a maximum static power of 62 kW. At 4,000 rpm this reduces to approximately 25 kW.

The cylinder barrels are air cooled and the cylinder heads are water cooled. It is fitted with self-sustaining, dual electronic ignition systems to operate the two spark plugs fitted to each cylinder.

It has two carburettors, one at the rear of each pair of cylinders. Fuel is supplied from the aircraft fuel system by an engine-driven fuel pump installed near the front of the engine. Because of the relative location of these components, the fuel pipes are routed across the top of the engine to connect them.

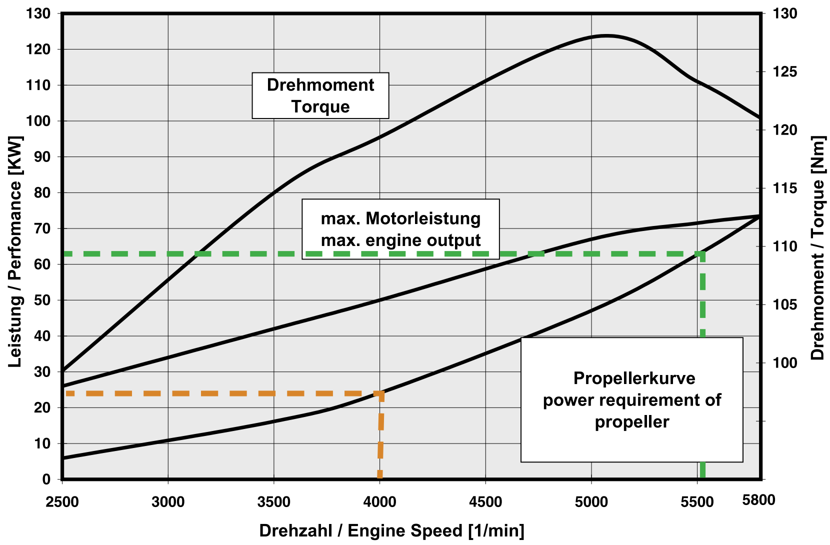

Figure 1

Engine performance graph

This aircraft was fitted with an optional carburettor heat system modification which used the hot water from the cooling system to heat the carburettor bodies and thereby prevent carburettor ice formation.

The ground-adjustable, fixed-pitch propeller on this aircraft was driven via a reduction gearbox.

Fuel system

The fuel tank is installed in the fuselage behind the seats. It is saddle-shaped to fit around the pitch and flap control push rods. This arrangement provides a main tank of approximately 60 litres and a reserve tank of approximately 9 litres. The fuel filler is connected to the right hand side of the tank, and as fuel is added the right hand side fills first and therefore is designated the RESERVE tank. When the reserve side is full, additional fuel then flows over the saddle into the other side and upper part of the tank, which is designated the MAIN tank (Figure 3).

Fuel outlets are provided from both the main and reserve tanks. These are fitted with a coarse mesh filter to prevent larger debris blocking the fuel outlet. A selector valve enables the fuel supply to be selected to MAIN, RESERVE or OFF. From the selector valve the fuel is piped via an electric fuel pump and a fine fuel filter to an engine-driven fuel pump and then to the dual carburettors. A fuel vapour return line is fitted in the fuel line between the carburettors, this is to allow any fuel vapours to return to the tank and dissipate though the tank vent system. This fuel vapour return line is fitted with a restrictor orifice to limit fuel flow.

Accident site

The accident site was located in a field approximately 200 m south of the runway at Coal Aston Airfield (Figure 2). The aircraft was inverted and the evidence indicated it had struck the ground in a steep nose-down attitude. The ground was hard; a thin layer of turf covered a hard stone sublayer. In addition to the main fuselage impact point, a clear mark in the ground was made by the leading edges of the wings.

The main wreckage came to rest approximately 19 m from the initial impact marks. Most of the wreckage was within the area between the main wreckage and the ground marks. A notable exception was a substantial piece of a propeller blade which was found approximately 39 m from the initial impact point and perpendicular to the wreckage trail.

There was no fire.

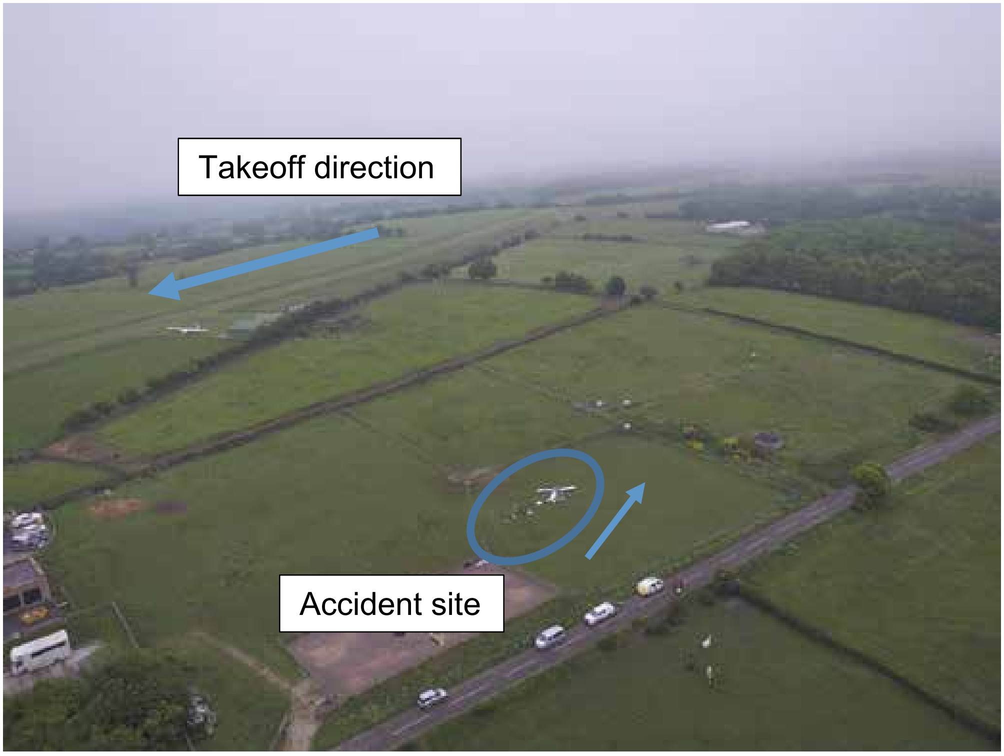

Figure 2

Coal Aston Airfield and the accident site

Initial assessment of the wreckage

Although the aircraft was severely disrupted by the impact, the wings and tail surfaces remained attached to the fuselage. Due to the impact angle the fuselage had crumpled in the area of the cockpit and the engine and the rear fuselage had detached.

It could be confirmed that prior to the accident the flying controls were intact and there was no evidence to suggest that they would not have operated normally. The elevator trim position was found in a normal flight position.

It was not possible to conclusively determine the position of the landing gear and flaps, which operate together from a single lever, but the evidence indicated it was most likely that they were in the retracted position.

The instrument panel was heavily disrupted and fragmented so it was not possible to determine pre-impact switch positions. A number of instruments were found with the indicating needles stuck in a position. The rpm indicator was stuck at 4,100 rpm and the fuel pressure gauge was stuck at 0.14 bar, which is below the minimum fuel pressure specified by the engine manufacturer of 0.15 to 0.40 bar.

The fuel selector valve was found selected to the MAIN tank position as indicated by its placard.

The senior fire officer at the scene stated that when he arrived fuel had been leaking from the fuel tank vent line, it was sealed to prevent further leakage. The fuel quantity on board at the time of the accident was therefore more than the 40 litres recovered from the fuel tank.

Recorded information

The pilot carried a tablet computer with him in the aircraft, but it was damaged in the accident and it was not possible to retrieve any information from it.

Detailed examination of the wreckage

Fuel system

The fuel system on the aircraft was found to be in good condition and its installation was similar to the manufacturer's recommended design configuration but with some notable differences (Figures 3 and 4).

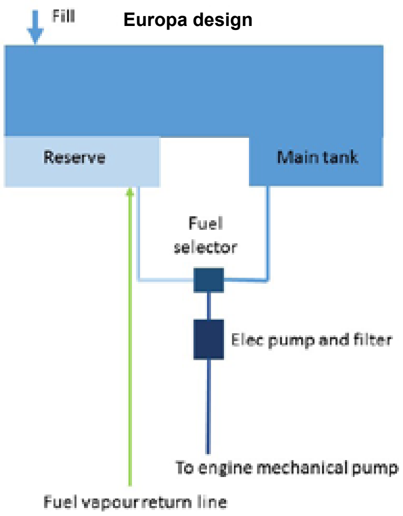

Figure 3
Fuel system schematic based on Europa build manual

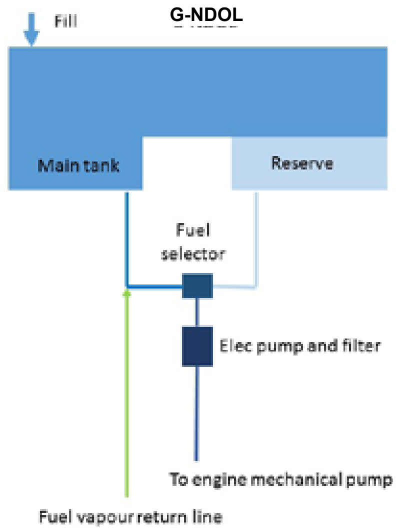

Figure 4
G-NDOL fuel system schematic

The fuel selector was configured such that the left side of the tank was used as RESERVE and the right side and remainder of the tank was designated as MAIN. This configuration was indicated by a placard close to the selector. This was the original design configuration but it was amended, by Europa, to the current configuration early in production.

No coarse fuel filters were found on the tank outlet fittings.

The fuel vapour return line was routed to a ‘T’ fitting on the fuel selector where it combined with fuel from what had been configured as the main tank (Figure 5).

The fuel lines from the fuel tank to the selector valve and the fuel vapour return line from the engine were all of a similar flexible type with a stainless steel braid cover and threaded metal end fittings. The outlet from the fuel selector to the fuel pumps and to the fuel filter were rigid aluminium lines. A flexible type with a stainless steel braid cover was fitted from the fuel filter to the engine-driven fuel pump. The fuel lines from the engine-driven fuel pump to the carburettors were plain flexible lines with push fit connectors secured with screw type hose clips; these lines appeared to be relatively new.

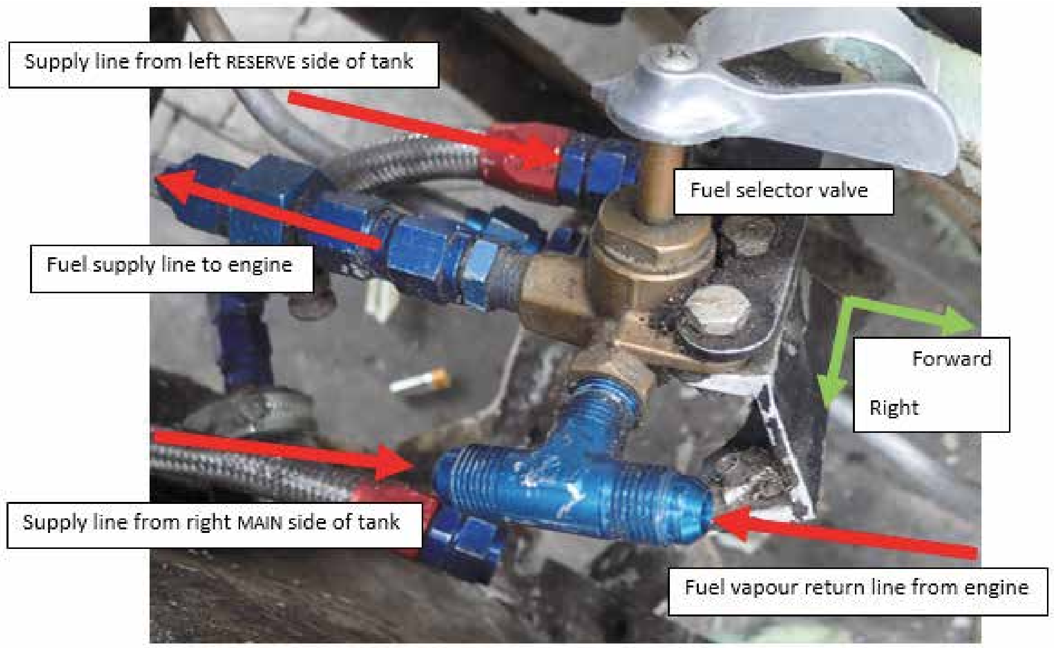

Figure 5

Fuel selector valve showing ‘T’ fitting on inlet from right side of tank

Testing of fuel filter

The fuel filter assembly was removed and its sintered bronze filter element was inspected. It was found contaminated with general dirt and debris which included insect remains (Figure 6).

Figure 6
Fuel filter element showing contamination found

A flow test was carried out to determine the degree of restriction caused by the debris. The first test was carried out using the filter element fitted at the time of the accident and the test was then repeated with a new element. On both occasions fuel was supplied to the filter by the electric fuel pumps from the aircraft. The results from both the old and the new filters were similar and the fuel flow recorded was well in excess of that required by the engine at full power.

Fuel testing

A sample of the fuel recovered from the fuel tank was tested by a specialist facility. It was found to be consistent with forecourt unleaded fuel to EN228 specification and it contained 4.5% ethanol (E5 Mogas). No records indicating where or when the fuel was sourced were found.

Approved fuels

Historically, suitable LAA aircraft had been able to operate on unleaded Mogas fuel to EN228 standard (forecourt unleaded fuel). In around 2010 fuel companies started to introduce ethanol into this fuel to preserve fossil fuels. Nowadays fuel companies are required by European law to blend bio-fuel into their fuels and the normal choice is ethanol, currently not exceeding 5% by volume and is designated E5 Mogas.

Until late 2014 the UK CAA prohibited the use of Mogas containing ethanol in single engine piston aeroplanes, but at this time it transferred responsibility for choice of fuel and provision for appropriate guidance to the aircraft's type design organisation. For aircraft operating on an LAA Permit to Fly this is the LAA.

The LAA issued guidance in Technical Leaflet TL 2.26; '*Procedures for use of E5 unleaded Mogas to EN228'* which is available from their website. It includes the procedure for clearing eligible aircraft to use E5 Mogas and directs owners to download the relevant inspection checklist to use. This checklist is then verified by an LAA inspector and, if satisfactory, details are entered in the aircraft's engine and airframe log books. The check list for the engine installed on this aircraft includes the following inspection:

> *'A vapour return line must be fitted, to circulate a small amount of surplus fuel and any vapour back to the fuel tank, via a restrictor orifice of around 0.35 mm diameter. Refer to Rotax 912/912S Installation Manual for details.'*

The Rotax 912/912S Installation Manual, which is applicable for the 912ULS, includes the following note:

> *'NOTE: The* [vapour] *return line prevents malfunctions caused by the formation of vapour lock'*

Details of operational limitations are discussed in the leaflet and the following placard summarising these limitations is described. It must be fitted on the instrument panel, or a similar place and in clear view of the pilot.

> ***'USE of E5 Mogas***
>
> - *only legal in aircraft specifically approved for the purpose*
> - *fuel to be fresh, clean, water free and not exceed 5% alcohol content*
> - *verify take-off power prior to committing to take-off*
> - *tank fuel temperature not above 20º C*
> - *fly below 6000 ft*
>
> *WARNING – CARB ICING, WATER CONTAMINATION AND VAPOUR-LOCK MORE LIKELY'*

This aircraft and engine combination can be approved to use E5 Mogas and although G-NDOL was fitted with the required placards, no log book entry or checklist could be found to show the required procedure to use E5 Mogas had been completed or verified by an LAA inspector.

Aircraft maintenance history

The aircraft had been issued with a Permit to Fly and its certificate of validity was in date.

The most recent flight test for the Permit to Fly was conducted on 6 July 2016. The engine static rpm was recorded as 5,550 rpm, and the climb rpm as 5,350 rpm. The propeller was subsequently replaced.

Entries in the aircraft log book record that fuel was drained from the aircraft in October 2016 and then it was refuelled in March 2017.

The last Annual Permit Renewal Inspection was completed satisfactorily on 28 June 2016.

The LAA inspector completing the inspection recalled:

> *'some of the engine compartment fuel hoses, which although still serviceable at the time, would need replacing at some stage in the future.'*

The aircraft log book entry for the Annual Permit Renewal Inspection in April 2014 recorded that some of the fuel lines on the engine were showing signs of wear. They were replaced.

Analysis of the aircraft and engine logbooks show that between June 2006 and June 2011 the were a number of reports of the engine 'rough running'. Significant rectification work was undertaken following these reports which included checking and replacement of parts in the fuel and ignition systems. There were no subsequent reports of 'rough running' in these log books. The pilot's personal flying logbook entry for 18 July 2016 contained an annotation '*Vapour lock – not nice*'.

In March 2007 the aircraft was inspected by an LAA inspector in accordance with checklist PFA/ULM2 to allow Mogas [with no ethanol] to be used. This checklist included the requirement to check a fuel vapour return line was fitted and connected to the tank.

When the Rotax engine was installed in 2002, the LAA inspector who inspected the installation recalled that the fuel vapour return line was routed along the right hand side of the aircraft and into the fuel tank via a fitting on the right hand side of the fuel tank.

There are no log book entries relating to changing the routing of the fuel vapour return line and it could not be determined when the change was made.

Pathology

Post-mortem and toxicological examinations were conducted on the pilot on behalf of the Coroner. There was no evidence of any medical or toxicological factor which could have contributed the accident.

Other information

The aircraft was kept in a steel hangar on the airfield. On a sunny day, temperatures inside such a building are likely to be higher than ambient.

A friend of the pilot, who also flew at the Coal Aston Airfield, had researched the ethanol content of Mogas available at different petrol stations around the local area. He found a local station where the ethanol content was tested as zero and both he and the pilot normally purchased their fuel in jerry cans from there.

In 2015, the friend had researched fields which might be available for a forced landing in the event of an engine failure after takeoff on Runway 29. He considered there were limited options but there was one field ahead he thought suitable if sufficient height was gained by the end of the runway. He had discussed its location with the accident pilot and practised a takeoff technique to gain maximum height while over the airfield.

Partial loss of engine power

A partial loss of engine power after takeoff presents a more complex decision to a pilot than a complete engine power loss. With an engine that is still providing some power, a pilot can be led to consider a turnback towards the runway instead of accepting a forced landing ahead. However, in turning back, they may then find themselves in a worsening situation; manoeuvring and turning downwind at low level and low speed carry a significant risk of loss of control. Additionally, engine power may be unreliable resulting in a total power loss at a potentially critical time.

The CAA published in May 2017 the Skyway Code[1] containing safety information for General Aviation. Guidance is provided concerning partial engine failures:

> *'Particularly at low level, focus on maintaining speed and control. Provided you keep the aircraft at flying speed and under control, engine failures are unlikely to be fatal.*
>
> *Partial engine failures can confuse the decision making process. Assess whether the failure is likely to become worse – for example if rapidly losing oil pressure, the engine may not run for much longer. Take a positive decision to either put down in a field or continue to an aerodrome, depending on your judgement of the problem.'*

A publication by the Safety Promotion Unit of the Civil Aviation Authority of New Zealand in 2013[2], concerning engine partial power loss advised:

> *'Many occurrences result in fatalities or serious injury due to pilots losing control of their aircraft after an engine partial power loss, especially in the takeoff phase of flight.'*

The article emphasised the importance of considering the options in the event of a partial power loss at the pre-flight planning stage and reviewing them again immediately before takeoff.

ATSB Transport Safety Report '*Aviation Research and Analysis - AR-2010-055 Avoidable Accidents No. 3 Managing partial power loss after takeoff in single-engine aircraft*'[3] provides information and guidance on partial engine power loss events and advises:

> *'Partial engine power loss is more complex and more frequent than a complete engine power loss.'*

Footnote

1 http://www.caa.co.uk/General-aviation/Safety-information/The-Skyway-Code/ [Accessed 24 August 2017]
2 https://www.caa.govt.nz/assets/legacy/Publications/Vector/Vector_2013-3.pdf [Accessed 18 August 2017]
3 https://www.recreationalflying.com/tutorials/safety/ATSB_ar2010055.pdf [Accessed 27 August 2017]

Analysis

Operational aspects

On the day of the accident the weather conditions were good; it was warm but not hot. The aircraft was kept in a hangar where the temperature may have been higher than the ambient, thus the temperature of the fuel may have been above 20 °C. The pilot moved the aircraft out of the hangar and then went on a local flight for around 20 to 30 minutes. The aircraft was parked outside for a while before he took off and flew a short 'hop' along the runway. Although the reason for this 'hop' was not determined the pilot did not mention having experienced a problem to anyone at the airfield.

The aircraft was seen to take off on the accident flight but it did not achieve a 'normal' rate of climb. The engine power was reduced although it was still producing power at impact; evidence from the wreckage and witnesses suggests it may have been operating at approximately 4,000 rpm. This would represent about 40% of takeoff power, probably sufficient to maintain level flight or a small climb gradient but any turn would diminish this performance. An aircraft's rate of climb is dependent on the difference between the available engine power and the power required for level flight; hence a modest reduction in engine power can result in a significant reduction in climb performance.

The evidence from the accident site suggests that the landing gear and flaps were retracted at impact. If so, this would indicate that the pilot was not aware of any problem until after he had lifted off from the runway and performed the single action of gear and flap retraction. The aircraft was at an estimated height of 100 ft to 150 ft when the left turn began; starting to turn at such a low height suggests the pilot was aware of a problem. There was approximately 160 m of open ground ahead before the hedgerow but beyond that options for a forced landing were somewhat limited. The partial loss of power could have led the pilot to consider a turnback, believing he could maintain height, but in the takeoff phase as soon as any turn is started the associated reduction in climb performance is likely to require a descent to maintain airspeed. In contrast, a total power loss at low level does not usually offer the option of a turnback with its risk of a loss of control, because an immediate landing ahead is required. The ground cues during the low level turn downwind could have given the pilot an impression of an increasing and higher than actual airspeed, and thereby led to a stall. Any pre-stall indications of buffet would have been very brief; a recovery from such a low height would not have been possible.

Engineering aspects

The evidence from the accident site together with the eye-witness accounts suggest that the aircraft had stalled prior to ground impact.

Inspection of the aircraft did not reveal any anomalies that would have affected its ability to fly or be controlled. The aircraft and pilot log books recorded a previous history of problems with engine power, including on one occasion '*vapour lock*'. The reason for these problems does not seem to have been resolved, as evidenced by the entry for July 2016.

There was one significant anomaly relating to the fuel system that may have been relevant to the accident. The fuel vapour return line was connected to the inlet of the fuel selector valve, rather than to the fuel tank. This would have the effect of routing any fuel vapour that formed in the fuel system back to the engine instead of returning to the fuel tank to dissipate.

The two flights conducted earlier in the day meant the aircraft would have been parked with a hot engine. The warm fuel, heat soak from the hot engine and the fuel system installation in the aircraft made the aircraft more susceptible to the formation of fuel vapour, especially when using E5 Mogas. Limitations that are stipulated with the approval for using this type of fuel make reference to this.

Due to the installation of the fuel system on G-NDOL any fuel vapours that formed would not have been dissipated to atmosphere via the fuel tank vent as designed, but instead they would be recirculated back into the fuel supply to the engine and thereby increasing the risk of a disruption to the fuel supply to the engine.

The aircraft was using E5 Mogas, and although it was eligible to use this fuel, no evidence of the relevant procedures to approve its use could be found. The checklist that is completed as part of this procedure includes an inspection to ensure a fuel vapour return line is installed to route any fuel vapours back to the fuel tank.

A similar inspection to approve the use of Mogas had been satisfactorily completed in 2007, it contained the same requirement to check the installation of a fuel vapour return line.

The available evidence indicates that fuel vapour probably formed in the fuel supply to the engine. Anomalies with the fuel system meant that any vapour that formed might not dissipate effectively. Instead, it would have been returned to the engine where it is likely it would disrupt the fuel supply to the engine reducing the power it was able to produce.

Conclusion

The aircraft suffered a partial loss of power shortly after takeoff, probably as a result of fuel vapour disrupting the fuel supply to the engine. The likelihood of vapour lock was increased by the incorrect routing of the vapour return line into the fuel selector valve rather than the fuel tank. The pilot attempted a left turn downwind at low level, possibly intending to return to land at the airfield. The aircraft stalled in the turn at a height from which a recovery would not have been possible.

Safety action

The AAIB discussed the investigation findings with the LAA and the LAA took the following action.

On 19 July 2017 the LAA issued Airworthiness Information Leaflet LAA/MOD/247/010. This required a mandatory inspection, before next flight, of all Europa aircraft operating under an LAA administered Permit to Fly. The inspection was to check for the correct installation of a fuel vapour return line. Details can be found on the LAA website.

ACCIDENT

Aircraft Type and Registration:	Yak-52, G-YAKB
No & Type of Engines:	1 Ivchenko Vedeneyev M-14P radial piston engine
Year of Manufacture:	1992 (Serial no: 9211517)
Date & Time (UTC):	8 July 2016 at 0934 hrs
Location:	1 nm north of Dinton, Wiltshire
Type of Flight:	Aerial work
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 1 (Fatal) 1 (Serious) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	2,953 hours (of which 446 were on type) Last 90 days - 18 hours Last 28 days - 15 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was conducting a flight for a test pilots' school. The commander, a civilian flight instructor, was in the rear seat and a tutor from the school occupied the front seat.

Shortly after completing a series of aerobatic manoeuvres, the engine lost power without warning. Attempts to restore power were unsuccessful and, at about 1,100 ft agl, the commander committed to a forced landing in a field. Evidence showed that the pilots probably became aware of a farm strip late in the approach to the intended field and made an attempt to land on the strip. The forced landing was unsuccessful and the aircraft struck the ground in a steeply left banked attitude at the southern edge of the strip. The tutor was fatally injured and the commander sustained serious injuries.

The cause of the loss of engine power was not determined, but the reported symptoms were indicative of a fuel system problem.

One Safety Recommendation is made concerning the maintenance of seat belts and harnesses.

Background information

The aircraft was operating under a contract with a test pilots' school at Boscombe Down (BD), Wiltshire. The work was sub-contracted to a Flying Training Organisation (FTO). The FTO had further sub-contracted the work to the aircraft's commander, a civilian flight instructor, who was experienced on the Yak-52.

The aircraft was being employed for a Qualitative Evaluation (QE). This is part of the Test Pilots' course where different aircraft types are brought to BD, under contract, for short-term use. This gives the test pilot students and flight test engineer students experience of multiple aircraft types and the opportunity to fly a test scenario with a 'safety pilot' (the aircraft's commander). The Yak-52 was used to expose the students to an Eastern European aircraft. There was also a requirement for 'tutors'[1] from the school to experience flying the aircraft type.

The Yak-52's commander had participated in QEs, with a Yak-52, annually since 2010. He occupied the rear seat when flying with test pilot students and the front seat when flying with flight test engineer students.

On Sunday 3 July 2016, G-YAKB was flown from its base to BD by the commander with the exercise tutor who had organised the QE. The following day the commander and exercise tutor flew a flight profile similar to a QE, prior to the commander flying with the students. This was to demonstrate to the commander BD's local procedures and a QE sortie profile. The flight did not include any simulated emergencies. Later that day the commander also gave a 90-minute Technical and Safety Briefing on operating the aircraft, which included a cockpit familiarisation, to all the students and the exercise tutor. This briefing was deemed mandatory for any tutor intending to fly the Yak-52. The front seat pilot (FSP) on the accident flight, who was a tutor and a Royal Air Force (RAF) pilot, was not present at the briefing.

The AAIB investigation into this accident was conducted in parallel to, but independently of, a military Service Inquiry (SI) investigation. The SI investigation was launched because of the death in service of an RAF pilot. The SI investigation focussed more on the organisational and operational aspects of the test pilots' school and its oversight by the Ministry of Defence. The SI investigation report was published by the Defence Safety Authority on 15 June 2017[2].

Footnote

1 Test Pilot instructors at the school are called tutors.
2 https://www.gov.uk/government/publications/service-inquiry-into-the-aircraft-accident-involving-yak52-g-yakb-on-8-july-2016

History of the flight

This section was compiled using a combination of radar data, BD ATC radio recordings, witness statements and the commander's own recollection.

Prior to the flight

The FSP had originally been scheduled to fly in the Yak-52 late in the morning of the accident, after a student. However, the student was unfit to fly and so the FSP's flight was rescheduled to be the first flight of the day.

On the day of the accident the commander and FSP were described as being "bright and breezy" when they arrived at the school, with the FSP looking forward to the flight, not having flown the aircraft type before. The pilots were seen briefly in discussion before a meteorological brief and again afterwards, for about 15 minutes, prior to being "out-briefed" by the supervisor for the flight.

The aircraft had been kept overnight in a hangar; upon arrival, the pilots helped push the aircraft out onto the apron. The assisting engineer commented that they appeared rushed. The aircraft was then refuelled to about 1 cm below the brim, with a fuel uplift of 53 litres being recorded in the fuel bowser logbook.

The accident flight

After an uneventful start up and taxi out, the aircraft took off from Runway 23 at 0915 hrs[3], departing to the west of BD and climbing initially to about 5,200 ft amsl. It completed some aerobatic manoeuvres, between 3,400 ft and 5,200 ft amsl, some of which involved inverted flight, which the commander believed[4] were flown by the FSP. The pilots remained on the BD ATC Approach frequency throughout the flight.

The commander stated that after completing these manoeuvres, when the aircraft was at about 4,000 ft amsl and in a slow descent, the engine lost power without warning. The propeller continued to windmill. During this time the commander exercised the throttle, but this had no effect. He then returned the throttle to approximately its original position, which he believed was about 70% rpm. On checking the engine instruments he noted that the fuel pressure indication was zero. Believing that there may be a stuck "flapper valve" in the fuel lines, the commander took control and flew some high g turns to try to release the valves, but to no avail.

On the assumption that the engine-driven fuel pump had failed, the commander instructed the FSP to turn the fuel primer handle[5] to the left position and pump it in a bid to restart the engine[6]. He initially observed him doing so and recalled that the FSP was pumping at a rate of about once every 3 to 4 seconds. With each pump the engine started and

Footnote

3 All times in this report are UTC.
4 The commander had an incomplete recollection of events during the flight.
5 See *Fuel system description* for a detailed description of the fuel system.
6 See *Yak-52 emergency procedures* below for the engine failure in flight checklist.

accelerated momentarily, with associated power, before stopping again. The commander observed the fuel pressure increasing with each pump of the primer. During each restart attempt the engine sounded normal, with no additional noises that might have indicated a mechanical problem.

The commander continued to fly the aircraft while the FSP pumped the fuel primer handle and made radio transmissions to BD ATC when required. At 0930:32 hrs the FSP transmitted a MAYDAY stating "WE HAVE A MAJOR MAJOR MALFUNCTION", before requesting radar vectors to return to the airfield. ATC acknowledged this and advised the aircraft to turn onto a heading of 090° M. Shortly thereafter, ATC asked the aircraft to squawk the transponder emergency code of 7700, to which the FSP replied "UNABLE". At 0931:30 hrs, the FSP asked ATC for a range from BD; they replied 12 nm. At 0932:06 hrs, the FSP radioed that they were visual with the ground and "…PROBABLY GOING TO BE ER PFL'ING [practice forced landing] TO A FIELD ER WEST OF BOSCOMBE". At this point the aircraft was at 3,100 ft amsl (about 2,650 ft agl) and 10.5 nm from BD. ATC then transmitted the surface wind at BD, which was from 230° at 14 kt; this was acknowledged by the FSP.

The commander stated that at this point he had elected to continue towards BD, in case the engine recovered, while the FSP continued to pump the primer handle. The aircraft continued to descend throughout this time. Shortly thereafter, ATC informed the crew that the aircraft's range was 9 nm. Realising that the aircraft would not be able to reach BD, at 0933:29 hrs, at an altitude of 1,475 ft amsl (approximately 1,100 ft agl), the FSP transmitted "GOLF KILO BRAVO IS MAY [SIC] PFL'ING TO A FIELD JUST TO THE WEST OF BOSCOMBE [SLIGHT PAUSE] ER WILL PHONE YOU ON THE GROUND." This was the last transmission received by ATC. Figure 1 shows the radar track of the flight.

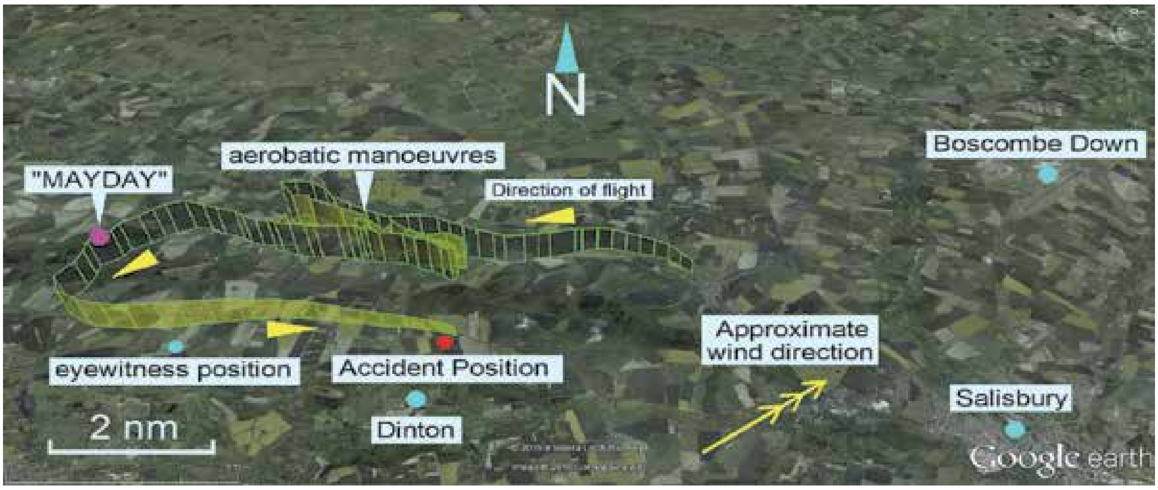

Figure 1
Radar plot of the flight (Clee Hill radar data)

Having decided to perform a forced landing, a large wheat field was identified and an approach to it established. During the approach a farm strip came into view and the commander had an "incomplete memory" that one of them had declared "there is an airstrip there", which was ahead and to the left. He stated that it would have been his decision to try to land on the strip as opposed to the chosen field. Figure 2 shows the relative positions of the final radar points and the accident site.

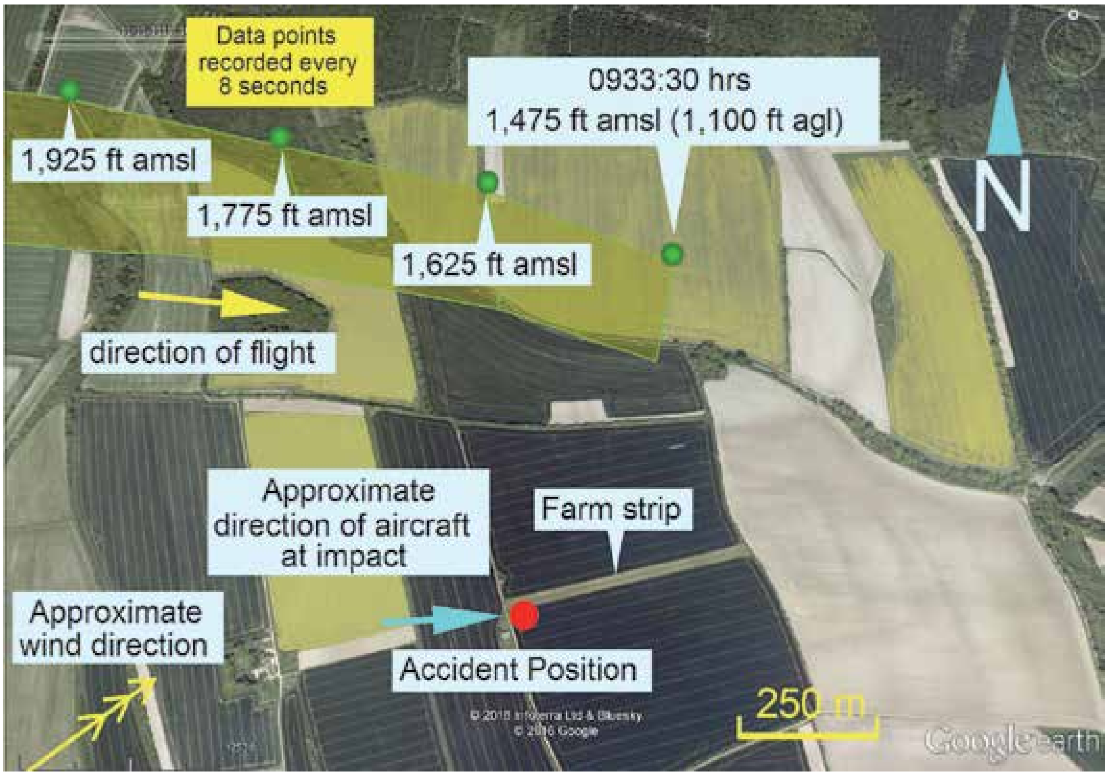

Figure 2

Final radar points (Clee Hill radar data)

The commander could not recall in which direction the aircraft turned after the last radar position, nor whether it was positioned to the north or south of the strip.

The attempt to land on the strip was unsuccessful and the aircraft struck the ground on the southern edge of the farm strip with its left wingtip, in a steeply banked attitude. The front of the fuselage broke up during the ground impact and the FSP was thrown clear of the aircraft.

A BD-based helicopter was operating in the vicinity around the time of the accident. On hearing the FSP's last transmission, the helicopter commander informed ATC that they were able to offer assistance and the helicopter was directed towards the aircraft's last radar position. Once visual with the Yak-52 on the ground, the helicopter landed close by and one of its pilots went to offer assistance to the Yak pilots. The FSP was lying unresponsive, close to the aircraft, and the commander, who was seriously injured, was in the rear seat. The helicopter pilot stated that the Yak-52 commander said to him "there was a landing strip wasn't there?" and that they came in steeply and he had to level off.

Another BD helicopter subsequently arrived, followed by two air ambulances and a Search and Rescue helicopter. Soon after, two local police officers (who attempted to resuscitate the FSP), the Rescue and Fire Fighting Services (RFFS) from BD and the local authority arrived at the accident site, as did an ambulance. The FSP was subsequently pronounced deceased at the scene. The commander was flown to hospital by air ambulance.

Eyewitness account

At about 0930 hrs, an eyewitness about 3 nm west of the accident site saw an aircraft just to the north, travelling in an easterly direction, on a constant heading. He stated that the aircraft was about 1,000 to 1,500 ft agl, above some low cloud. The engine sounded as though it was faltering; it then died completely before restarting again for a period of 4 to 5 seconds at high power. It then faltered again and stopped. The witness did not hear the engine start again. He was visual with the aircraft throughout this time. It then disappeared from his view because of cloud cover and some large trees.

Accident site

The aircraft wreckage was located in a wheat field on the southern edge of a private farm strip, 1 nm north of Dinton, at an elevation of 436 ft amsl (Figure 3). The private strip was not shown on any aeronautical chart or in any airfield guide and, according to its owner, was not easily visible from the air. The strip was 473 m long, 20 m wide and orientated in the direction 080°(M).

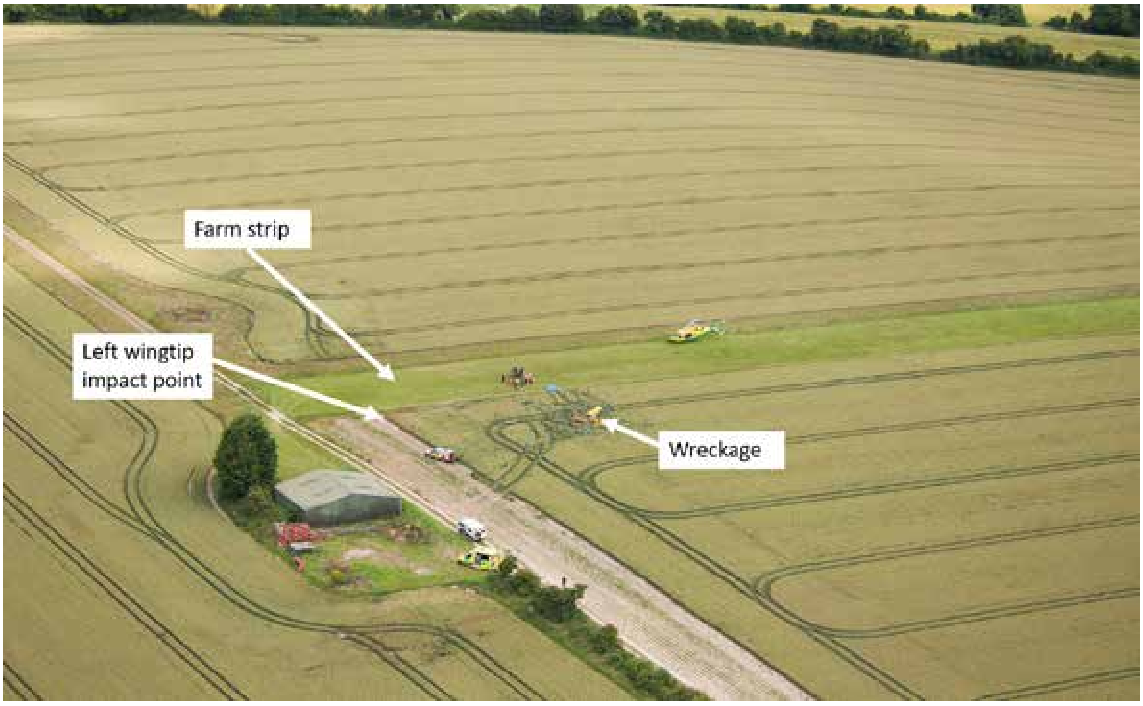

Figure 3

Aerial view of accident site (looking north) and private farm strip
(Photograph courtesy QinetiQ)

The ground impact marks showed that the aircraft had struck the ground left wingtip first, in a steep left bank; this was followed by a heavy nose impact (Figure 4). The aircraft had then bounced backwards, probably striking its tail, before bouncing again into the location where it was found, resting upright, 35 m from the initial impact point.

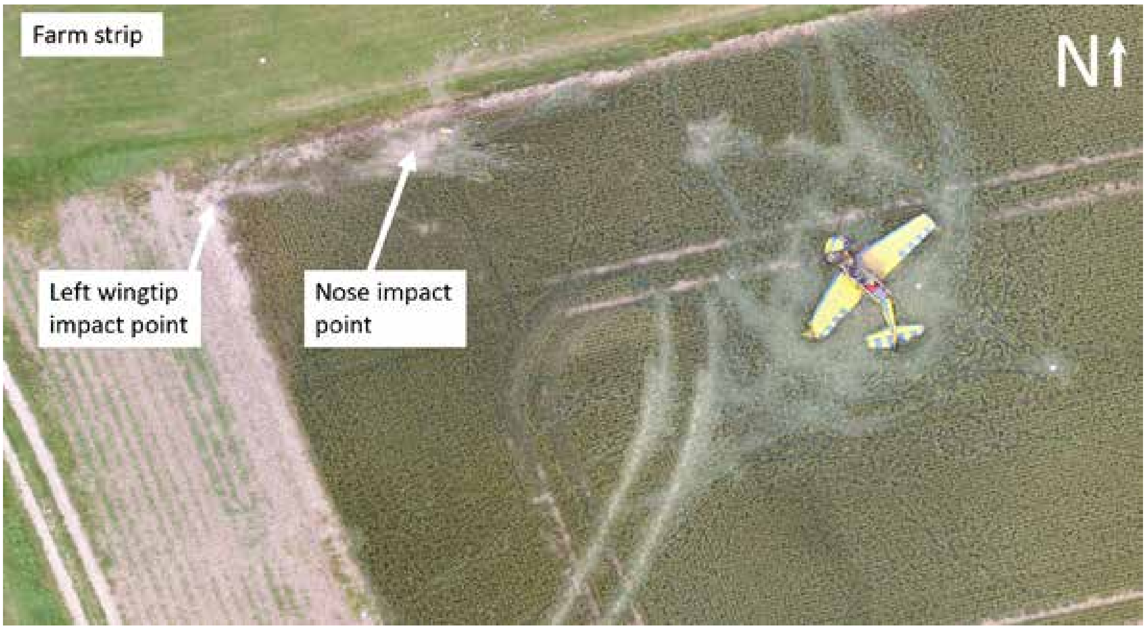

Figure 4
Aerial view of accident site (North up)

Recorded information

Final flight path

Radar data for the accident flight was recorded by various radar stations. The final secondary radar return, recorded at 0933:30 hrs by the Clee Hill radar (Figure 5), placed the aircraft on a bearing of about 025° from the accident site. At this point the aircraft was at 1,475 ft amsl[7] (1,100 ft agl) and approximately 0.32 nm (590 m) from the accident location. The last RT transmission was almost coincident with the final radar point. For the segment between 2,600 ft amsl and the final radar point, the average ground speed was 108 kt and the estimated average airspeed of the aircraft was 90 kt (167 km/hr), based on a wind from 264° at 18 kt[8].

Footnote

[7] This altitude was derived from Mode S transponder data which is transmitted in 25 ft increments.
[8] Derived from the Met Office information obtained from a weather balloon released at 0900 hrs from Larkhill, about 9 nm north-east of the accident site.

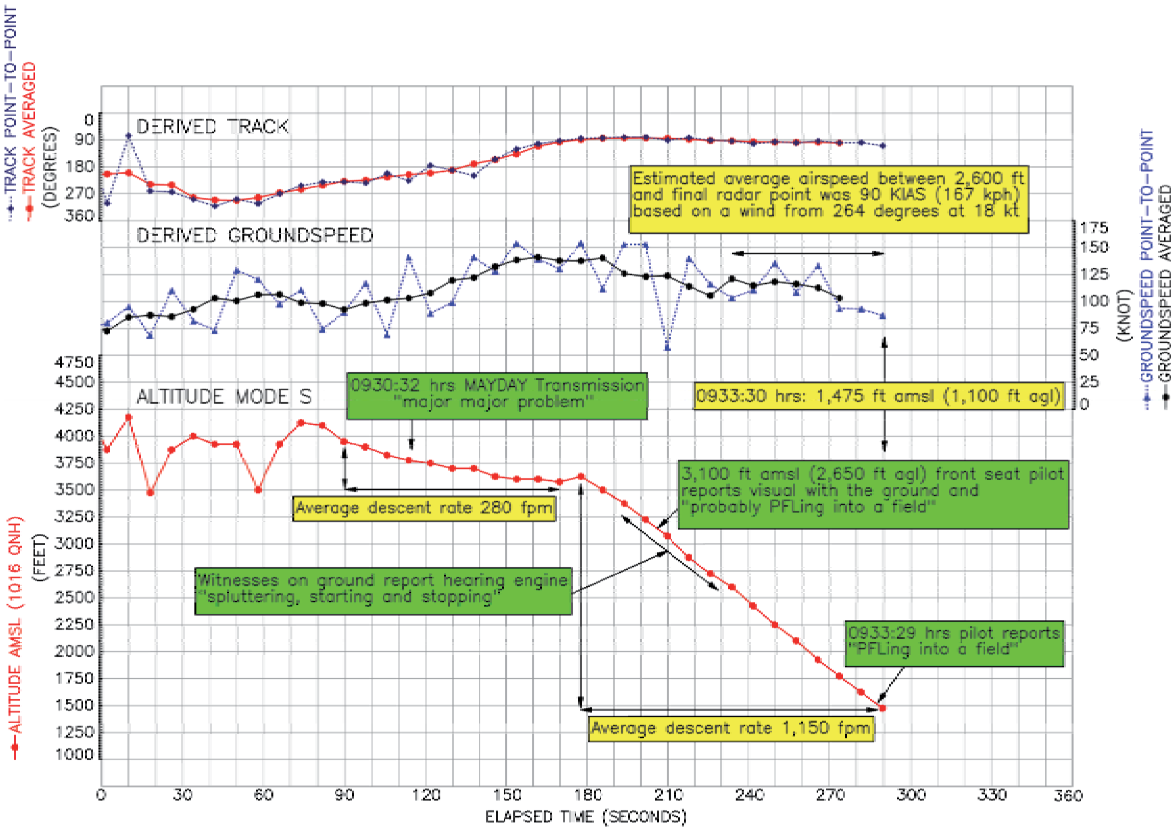

Figure 5

Accident flight radar data from the Clee Hill radar

Commander's comments

The commander was visited by the AAIB in hospital eight weeks after the accident and interviewed 12 weeks after the accident.

The commander stated that as the forward visibility from the rear cockpit was "very poor" he briefed some FSPs that, during a forced landing into a field, he would hand over control to them at an appropriate time, dependent on the situation, for them to do the landing. He had no recollection of who had control for the accident landing, though it is possible he handed control to the FSP. If this was the case, he believed he would have done so when the aircraft was straight on the final approach. He also said that the rpm gauges in both cockpits were intermittently serviceable during the QE week.

Although the rate of pumping of the primer handle did not allow the aircraft to maintain height, he did not ask the FSP to pump faster. The commander could not recall whether the FSP ceased pumping once the wheat field had been chosen for the landing.

Additionally, he had no recollection of the wind at BD, or if ATC had transmitted it after the MAYDAY was declared. He also had no recollection of what he had said to the helicopter commander after the accident.

Pilots' experience and qualifications

Commander

The commander held a current Flying Instructor rating and a Display Authorisation. He first flew the Yak-52 in March 2005, achieving a total of 446 hours on type at the time of the accident. He stated that about 80% of his Yak-52 hours were in the front seat, as the majority of his flying was competing in aerobatic competitions and display flying.

Prior to the 2016 QE, the pilot had last flown the Yak-52 on 16 March 2016, for one hour. His most recent logged experience in the Yak-52 prior to this was in July 2015, during the 2015 QE.

The commander had completed three successful forced landings in Yak-52s following previous engine failures. All of these had ended with the aircraft landing on a grass strip or an airfield, with the landing gear extended. He had landed the aircraft from the front seat on all three occasions. He had demonstrated PFLs onto an airfield from the rear seat when instructing on the Yak-52, but had not performed an actual forced landing from the rear seat.

The commander stated that he would normally conduct an off-airfield PFL to a minimum height of 500 ft agl and his target speed for forced landings in a Yak-52 was 180 km hr (97 kt). While this is greater than the published best glide speed of 160 km hr, he felt it was better to fly faster as it gave him more flexibility.

The commander had last supervised and/or demonstrated a PFL in a Yak-52, from the rear seat, during an instructional sortie on 16 March 2016.

Front seat pilot

The FSP was a qualified service pilot, test pilot and Qualified Flying Instructor. He also held a current ATPL (A) with Single Engine Piston (SEP) (Land) and Flight Instructor Ratings. He had a total of 5,773 military flying hours and 518 civilian flying hours. He had flown 62 hours in the preceding 90 days and 17 hours in the preceding 28 days.

His civilian logbook indicated that he last supervised and/or demonstrated a PFL on 5 June 2016 in a Diamond DA40 D, a SEP aircraft with side-by-side seating.

He had not flown the Yak-52 prior to the accident flight.

Test pilot students' comments

The AAIB interviewed several of the test pilot students and engineers who flew in the aircraft before the accident. They stated that the front and rear cockpit rpm gauges did not work, or did not work properly, and communications via the intercom and radio were of a poor quality. One added that the heading and attitude indicators in the rear cockpit were not working, the former of which was unserviceable before the QE commenced.

The extent of the emergencies brief given by the commander, before each flight, varied from, "if anything went wrong, he would take control and deal with the emergency" to "he specifically mentioned actions to be taken by the student in case of engine malfunctions that could not be performed by the pilot in the back seat". Another stated that the commander also talked about what the controls did and what the gauges showed, mentioning that the rpm gauge did not work properly. Others could not recall what was said.

Two of the test pilot students stated that they recalled performing all of the landings (about two to three each) from the front seat at BD and the commander did none from the rear.

Meteorology

An aftercast provided by the Met Office stated that there was a slow-moving cold front lying over the area of the accident, moving south-east. Surface observations from Larkhill[9] and METARs from MoD Boscombe Down[10] reported BROKEN stratus cloud between 600 and 900 ft agl at first, with bases lifting and cloud thinning later.

A radiosonde balloon released from Larkhill at 0900 hrs provided full details of the wind direction and speeds through the lower atmosphere. Table 1 shows some of the balloon's recorded wind data:

Wind direction and speed (kt)	Height of reading (GPS)
240°/10	133 m/436 ft
261°/16	471 m/1,545 ft
266°/19	604 m/1,980 ft
270°/24	793 m/2,602 ft

Table 1

Recorded wind data

Medical and pathological information

The FSP's post-mortem examination was carried out by a consultant histopathologist. Of note, he had serious head and facial injuries and fractures in his arms and hands, with his right hand more severely injured than his left. Additionally, he had serious injuries to the lower part of his legs.

Toxicological analysis of blood samples detected two antihistamine drugs which are used for the treatment of allergies such as hay fever. The levels indicated a previous, but not recent use. It was likely that this drug was taken at least 36 to 48 hours earlier and should not have had any detrimental effect on the FSP's ability to fly the aircraft.

Tests for alcohol were negative.

Footnote

9 Larkhill is about 433 ft amsl and 9 nm north-east of the accident site.
10 Boscombe Down Airfield is 407 ft amsl.

The post-mortem report concluded that he had died as a result of multiple traumatic injuries resulting from the accident.

Operational information

Permit to Fly

G-YAKB did not have a Certificate of Airworthiness but was operating on a Permit to Fly (PTF). The rules under which it must operate are in CAP 393, *Air Navigation: The Order and Regulations* (ANO). The extant version, published in 2015, stated:

> ***'23 Limitations of national permits to fly***
>
> *(1) Subject to paragraph (3), an aircraft flying in accordance with a national permit to fly must not fly for the purpose of:*
>
> *…*
>
> *(c) aerial work other than aerial work which consists of flights for the purpose of flying displays, associated practice, test and positioning flights or the exhibition or demonstration of the aircraft*[11]*.*
>
> *(2) No person may be carried during flights for the purpose of flying displays or demonstration flying (except for the minimum required flight crew*[12]*), unless the prior permission of the CAA has been obtained.*
>
> *(3) An aircraft flying in accordance with a national permit to fly may fly for the purpose of aerial work which consists of instruction or testing in a club environment if it does so with the permission of the CAA.*
>
> *…'*

The commander stated that he believed the aircraft was performing aerial work at the test pilots' school by way of demonstration flights, not instructional flights. He added that while he had not read the ANO he had been told it was acceptable to do demonstration flights in an aircraft with a PTF. Given this, and the fact that the flights were for the school, he believed this was appropriate.

The FTO that had sub-contracted the pilot stated that they did not believe approval to do aerial work was required from the CAA. This was because they believed an aircraft on a PTF could do aerial work for the purpose of demonstration and exhibition flying.

The test pilots' school stated that they thought the aircraft had a Certificate of Airworthiness and were not aware that the aircraft was operating on a PTF.

The CAA stated that they had not had any applications for a Yak-52 to do aerial work or to carry any additional persons while conducting a demonstration flight.

Footnote

11 The terms 'demonstration' and 'exhibition' were not specifically defined in the ANO.
12 G-YAKB's PTF states that the minimum flight crew is one pilot.

Yak-52 emergency procedures

The CAA stated that they do not approve a flight manual/pilot's notes for aircraft operating on a PTF. However, a checklist could be created from the information in a flight manual accepted by the CAA as appropriate for that aircraft and the relevant limitations/conditions to enable the safe operation of the aircraft would be stated on its PTF. The emergency procedures in the flight manual accepted by the CAA were comparable to the ones from the YAK-52 manufacturer's flight manual quoted below.

The commander provided the AAIB investigation with a checklist. He stated that there was not one in the aircraft as he had committed the aircraft's normal and emergency procedures to memory. When he flew in the front seat he described the checks he was performing to the rear seat occupant and when in the rear seat he talked the front seat occupant through the checks. The engine failure checklist read as follows:

> ***'ENGINE FAILURE***
>
> *Establish 172 KPH Glide*
>
> *Retract Landing Gear*
>
> *Check Mags, Fuel and Pump*
>
> *Turn Pump to left and pump fuel pressure to .1 to .2*
>
> *Attempt restart'*

The YAK-52 manufacturer's flight manual[13], published in 2002, had the following emergency checklists relevant to the symptoms reported by the commander:

> ***'5. IN-FLIGHT EMERGENCY CASES***
>
> ***5.1. PILOT'S ACTIONS IN CASE OF ENGINE SHUT DOWN DURING FLIGHT***
>
> *…*
>
> *5.1.3. If the engine stops during inverted flight:*
>
> - *perform a half-rolling and bring the airplane in normal flight:*
> - *set the gliding speed at 170-180 km/h:*
> - *bring the throttle lever at about one third of stroke:*
> - *bring the injection pump handle at 45º to the left and supply fuel until the fuel pressure at carburet[t]or intake is 0*.1-0.2 kgf/cm^2.
>
> *NOTE: To make the engine start easier, it is advisable to pump fuel in the engine cylinders* [right][14]*.*

Footnote

[13] The original flight manual was written in Russian. The manufacturer had translated it into English.

[14] Pumping fuel in the right position can assist engine start once the fuel pressure has been raised to 0.1 to 0.2 kgf/cm^2 by pumping in the left position.

5.1.4. As soon as the engine starts running again, bring the throttle lever in take-off condition [full power] for 1-2 seconds, then set the required flight condition.

…

5.3. PILOT'S ACTIONS IN CASE OF FUEL PRESSURE DECREASE

5.3.1. The fuel pressure decrease is signal[l]*ed by:*

- *discontinuous engine running accompanied by the deceleration of the engine speed, the reduction of the intake pressure and trepidations;*
- *the decrease of the fuel pressure as read on the control instruments, below allowed limits.*

5.3.2. In case of fuel pressure decrease the pilot must;

- *report to the flight controller;*
- *rotate the fuel pump lever 45º to the right* [left][15] *and start fuelling the fuel system, checking the pressure by reading the pressure gauges;*
- *interrupt the mission and land on the home- or auxiliary aerodrome.*

5.17. SPECIAL AIRPLANE FEATURES WHEN LANDING WITH DAMAGED ENGINE

5.17.1. …In case of a forced landing on a rough or unknown ground, the landing will be performed with the undercarriage retracted.

…

5.17.4 In case of emergency landing and engine failure, the pilot must perform the following operations:

- set the instrumental airspeed to 160 km/h;

…

- *shut the fire cock* [fuel shutoff lever]*, switch off the magneto, the generator, and the ignition;*
- *determine the height of flight…and calculate the available gliding distance so as to assess the possibility of landing on the aerodrome.*

Another flight manual, published by a UK Yak-52 maintenance organisation in 1995, additionally stated:

'Following an in-flight failure of the engine driven fuel pump the primer, set to CARB [left]*, may be used as an emergency fuel pump to maintain fuel pressure and thus enable the aircraft to be flown to the nearest diversion airfield.'*

Footnote

[15] The manufacturer stated that this procedure, as published, is incorrect and the pump lever should be turned to the left.

Yak-52 glide performance

The YAK-52 manufacturer's flight manual stated that after an engine failure the aircraft should be flown at 160 km/hr [86 kt], with the landing gear and the flaps retracted. The gliding range is calculated by multiplying the height by seven (a glide ratio of 7:1) and equates to approximately 1.15 nm per 1,000 ft. To ensure minimum height loss, turns should be flown with 45º angle of bank. A 360° turn, at best glide speed and with 45º angle of bank, has a radius of 200 m, a rate of descent of 8 m/s [1,575 ft/min] and a height loss of 220 m [720 ft].

A forced landing on rough or unknown ground should be carried out with the landing gear retracted, to reduce the risk of tipping over.

The commander had previously flown in a PA-28, a side-by-side seat aircraft, and a Bellanca 8KCAB, a tandem seat aircraft, with the most recent flights in March 2016. Their glide ratios are about 10:1 and 12:1 respectively.

Aircraft information

General

The Yak-52 (Figure 6) is an all-metal, two-seat, tandem, single-engine low-wing monoplane, designed by the Yakovlev Design Bureau in Russia as a basic aerobatic training aircraft and manufactured in Romania by Aerostar S.A.. The type first flew in 1978 and about 1,900 were built. Production ceased in 2010.

The aircraft type never received civil or military type certification. A number of Yak-52's and their similar single-seat version Yak-50's were brought to the UK in the 1980's and 1990's and operated on the Russian or Lithuanian register. From 2002 the CAA required that all Yak's be registered in the UK and operated under a PTF. Each aircraft brought onto the register received an Airworthiness Approval Note (AAN) listing its limitations and maintenance requirements. As of January 2017, there were 40 Yak-52's and 20 Yak-50's on the UK register.

Figure 6

The accident aircraft G-YAKB

The Yak-52 is powered by a 360 hp nine-cylinder, single-row, air-cooled radial M-14P engine[16] driving a two-bladed, variable-pitch wooden propeller via an epicyclic reduction gear. Mounted on the rear of the engine are a pressure carburettor and an accessory gearbox. The latter drives a single stage supercharger, a compressor, dual magnetos, a fuel pump, an oil pump, a tachometer and a generator.

The fuel consumption during aerobatic flying is reportedly about 90 litres/hr, and about 10 to 12 litres/hr at idle power. According to the flight manual the maximum range fuel flow is 37.3 litres/hr at 57% engine rpm and 192 km/hr (104 kt).

The electrical system is 28V DC, supplied by two batteries and the engine-driven generator. This is primarily used to power the aircraft instruments, radio and intercom. The flaps, landing gear and engine starting are powered by a pneumatic system fed by two air-filled pressure vessels which, in turn, are supplied by the engine-driven compressor.

The flight controls are conventional, with a central stick controlling the ailerons with push-pull rods and the elevator with cables; while pedals control the cable-operated rudder. The elevator trim is operated with a trim wheel and cable.

YAK-52 cockpit instruments and controls

On the left side of the front cockpit is a yellow throttle lever, alongside a propeller speed control lever (Figure 7). In front of these levers is a black fuel shutoff lever (shown red in Figure 7). The fuel shutoff lever is pulled aft to shut off the fuel in an emergency, and normally remains in the full forward position (as shown) at the end of a flight. These three control levers are replicated on the left side of the rear cockpit and each is mechanically connected to its counterpart in the front cockpit, so that the front and rear levers move in unison. The landing gear lever is on the left side of the instrument panel and has three positions: UP, NEUTRAL and DOWN. There is a manually-selected sliding safety gate on the selector to prevent the gear being selected up inadvertently on the ground. To select the landing gear down, the gear lever is pushed in and moved from UP to DOWN and the safety gate is slid to the right. The rear cockpit landing gear lever is normally left in the central NEUTRAL position, which gives priority to the front lever. The pneumatically operated landing gear can take up to 15 seconds to move to the fully locked down position. The flap lever is located aft of the throttle lever and has two positions, FORWARD and AFT to select flaps up or full down. The rear cockpit flap lever in G-YAKB was gated to render it inoperable.

The levers to control the engine cowl flaps and the carburettor heat are on the right side of the front cockpit; they are not replicated in the rear cockpit. On the right side of the front instrument panel are the fuel gauge and the fuel primer handle (Figure 8). The fuel gauge uses small light bulbs to illuminate the fuel quantity in the left and right main tanks. The fuel primer handle has three positions: LEFT, CENTRE and RIGHT. The function of this handle is described in the fuel system section of the report.

Footnote

[16] The majority of M-14P engines, including the one on G-YAKB, were manufactured by the Voronezh Mechanical Plant (VMP).

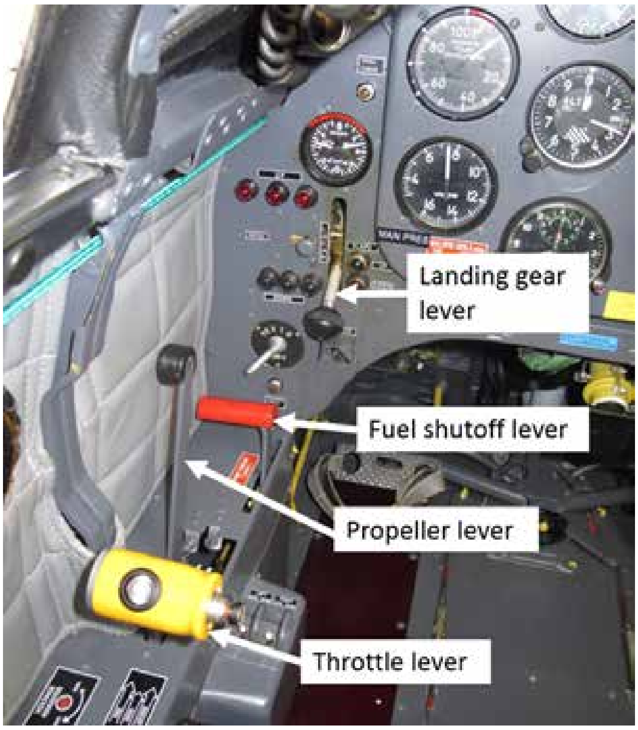

Figure 7

Front cockpit controls (left side) from a different Yak-52.
Fuel shutoff lever shown in the forward 'fuel on' position.
On G-YAKB the fuel shutoff lever handle was black

Figure 8

Front cockpit controls (right side) from a different Yak-52

The rear cockpit altimeter in G-YAKB was placarded inoperative, as it had failed an accuracy test. There was no manifold pressure gauge in the rear cockpit, but there was one in the front. The front and rear heading indicators had been unserviceable for some time, although both wet compasses[17], on top of the instrument panel, were reportedly serviceable. The commander and some students who flew earlier in the week reported that the front and rear engine rpm gauges were not functioning correctly; they would either indicate zero, run backwards or sometimes work correctly. This did not have any effect on engine performance, but these gauges were needed for proper engine management. Students also noticed that the rear cockpit attitude indicator was not displaying a steady, usable horizon.

The minimum equipment requirements for a VFR aircraft, at the time of the accident, were: an airspeed indicator, an altimeter and a compass, of which a wet compass would have been appropriate.

YAK-52 fuel system description

The fuel system includes two wing tanks, each of 61 litres capacity, which gravity-feed a 5.5 litre collector tank in the lower centre section of the aircraft (Figure 9). The engine-driven fuel pump draws its fuel supply from the collector tank which provides a short-term supply of fuel for inverted flight (up to 2 minutes is permitted). There is no left/right fuel tank selector, so both tanks feed the collector tank continuously via non-return ('flapper') valves. The first pair of non-return valves prevent fuel from passing from one tank to the other. The third non-return valve prevents fuel from flowing from the collector tank back to the main tanks. A rubber flop-tube inside the collector tank is connected to the fuel outlet. The flop-tube is weighted at its end so that it rests at the bottom of the tank during normal flight and rests at the top of the tank during inverted or negative-g flight; this ensures that the outlet can always draw the fuel in the tank.

From the collector tank the fuel passes through another non-return valve, the fuel shutoff valve, a coarse fuel filter, the engine-driven fuel pump, a compensation tank, and a fine fuel filter, before entering the pressure carburettor. The compensation tank provides a pressurised fuel reserve because the pressure carburettor does not have an integral tank. Excess fuel from the compensation tank is returned to the collector tank via a restrictor. Fuel pressure is sensed between the fine filter and the carburettor and is displayed on both front and rear cockpit gauges.

The fuel shutoff valve is normally only used in the event of a fire or forced landing. Fuel downstream of the valve is sufficient to run the engine for about 1 minute at idle. There is no electric fuel boost pump as seen on many low-wing certified aircraft, so if the engine-driven fuel pump fails, the engine will suffer a complete loss of power. Later model Yak-52W and TW variants are fitted with an electric fuel boost pump.

A manual primer handle, installed in the front cockpit, is used to start the engine. When turned to the left 'System' position (labelled 'Manifold' in Figure 8) and when pulled out and

Footnote

17 Wet compasses requires a steady flight path in order to be read accurately.

pushed in, the plunger in the handle draws fuel from a position upstream of the collector tank, as shown in Figure 9, and pumps it into a position between the collector tank and fuel shutoff valve. This primes the fuel lines, fuel pump and carburettor for engine start. When the primer handle is turned to the right 'Cylinder' position and pumped, fuel is drawn from the same location but is pumped into the supercharger compressor. This provides some vapourised fuel ready to be drawn into the cylinders as soon as the engine is turned over.

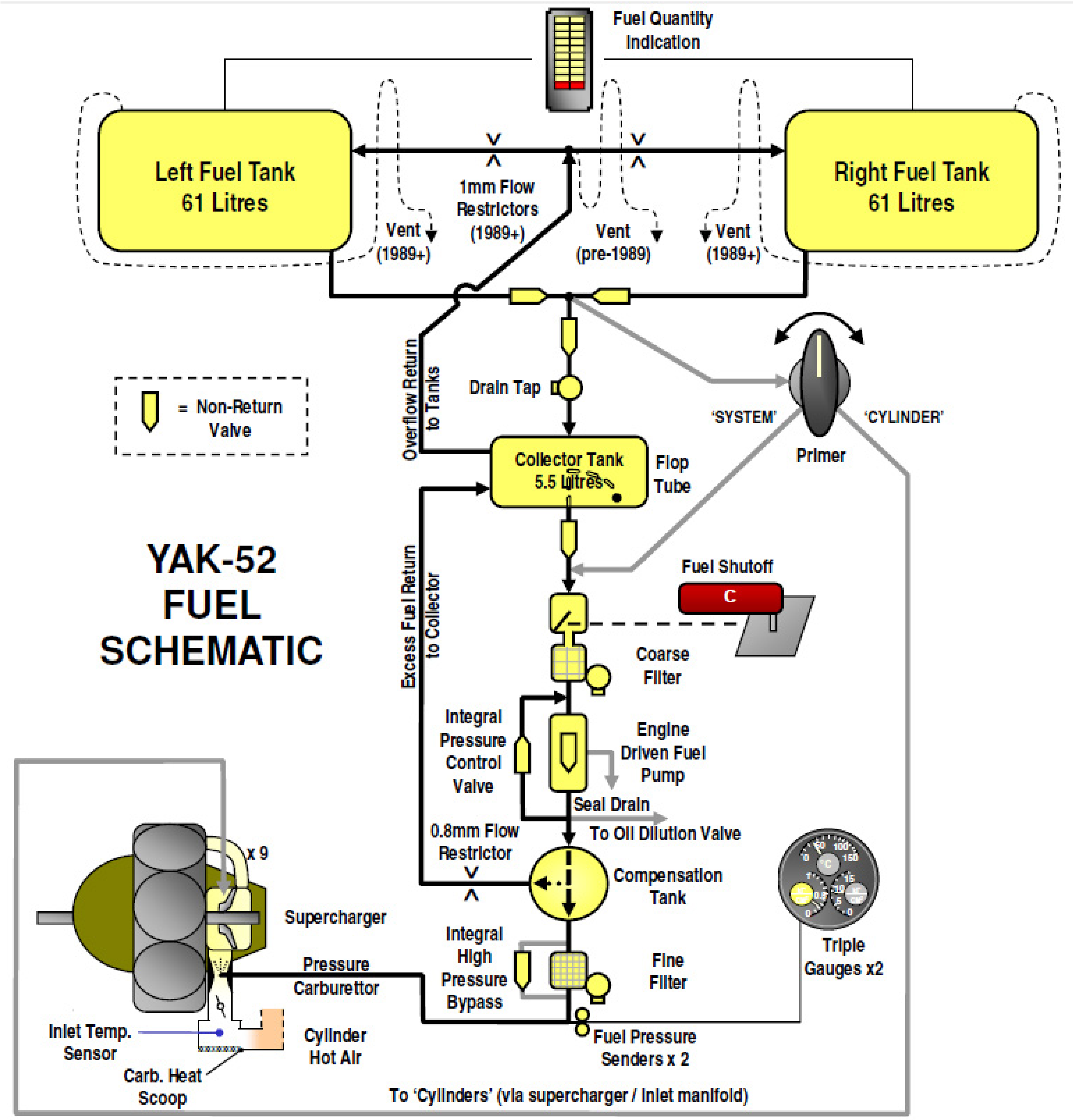

Figure 9

Yak-52 fuel system diagram (© Robert A. Rowe)

According to an unofficial flight manual and from anecdotal evidence, the primer handle can be used in the left 'System' position to maintain some engine power after a fuel pump failure. However, the aircraft manufacturer does not specify a rate at which the primer handle needs to be pumped to maintain level flight.

If the primer handle is pumped in the right 'Cylinder' position following a fuel-related loss of power, then unmetered fuel would be pumped into the engine, possibly causing brief bursts of power but not sustained running.

According to a Yak expert, the engine-driven fuel pump is very sensitive to ingested air. The pump will not easily suck air, so if sufficient air is introduced into the fuel upstream of the fuel pump the fuel pump may not be able to draw any fuel.

The pressure carburettor requires fuel to be delivered under pressure because it does not have a float chamber. The lack of a float chamber means that it will work while inverted, but the disadvantage of this design is that it must be constantly fed with pressurised fuel. Any air or vapour in the fuel in the carburettor can result in the engine losing power almost instantly. This is why significant priming is important for engine start.

Maintenance history

The aircraft was being maintained in accordance with the CAA's Light Aircraft Maintenance Schedule (LAMS/A/1999/Issue 2).

At the time of the accident the airframe had logged 500 hours and the engine had logged 516[18] hours. The propeller was overhauled in 2013 and had logged 48 hours.

In 2013 the aircraft underwent a CAA-approved lifetime extension inspection which extended the airframe's original 20-year life by 10 years. During this inspection an automotive spark plug conversion, in accordance with a CAA modification approval, was carried out. All the flexible fuel and oil hoses, and the carburettor diaphragm were replaced in December 2014. The last annual inspection was completed in February 2016 at 479 airframe hours.

According to the aircraft's AAN, the engine was due its first overhaul at 750 hours, and subsequent overhauls every 500 hours, with a maximum life of 2,250 hours. The engine on G-YAKB had logged 516 hours, so it was not yet due its first overhaul. The records indicated that the engine had been fitted to G-YAKB since build, so had been in service for 24 years without an overhaul. The original Russian engine logbook specified a first engine overhaul after 750 hours or 6 years[19]. There was no calendar overhaul life defined in the AAN. However, the CAA stated that their engine overhaul life principle was for operators to use the manufacturer's specified overhaul life and justify any changes. CAA CAP 747 '*Mandatory Requirements for Airworthiness*', Generic Requirement No. 24 '*Light Aircraft Engine Overhaul Periods*', allows engines in aircraft only used for private flying to continue in service indefinitely, subject to certain conditions. However, for aircraft being used for aerial work the calendar overhaul life limits apply unless an alternative life can

Footnote

18 Prior to 2002 the aircraft was registered in Lithuania, where a percentage of the engine ground running time was included in the engine total time.

19 According to the Russian Air Accident Investigation Commission, at the first 6-year overhaul the overhaul organisation decides the next calendar overhaul period, which would be 6 years or less, and this would be entered in the logbook. This applies to engines manufactured by VMP.

be justified[20]. Since no Yak-52 operator has yet approached the CAA for permission to conduct aerial work, the CAA could not state what alternative life, if any, would be approved.

Aircraft examination

Airframe examination

The airframe had suffered significant damage to its nose; from the front instrument panel forwards it was almost completely detached from the rest of the airframe. The left wing leading edge and wingtip had suffered crushing damage. The right flap was almost up and the left flap was down and angled forwards, although this was explained by the rod connecting the left flap to its actuator having failed. The front flap lever was in the up position and the lack of damage to the flap trailing edges indicated that the flaps were up at impact. The front landing gear lever was in the DOWN position with the safety gate closed, while the aft landing gear lever was in the NEUTRAL position. The nose landing gear leg and its actuator had suffered significant damage and disruption, indicating that it had probably been down or partially down at impact. The right main landing gear leg was up but not locked, while the left main landing gear leg was up and locked.

The flight controls were examined and there were no disconnections apart from breaks associated with impact damage. The elevator trim tab was in a near neutral position.

The engine controls were examined and there were no disconnections apart from breaks associated with impact damage. The throttle and propeller levers could have easily moved in the impact sequence, so their positions were not reliable pre-impact positions. The front fuel shutoff lever was in the aft closed position which corresponded to the position of the shutoff valve, but there was significant disruption to the control rods to the extent that the interconnecting aft fuel shutoff lever was in the open position; therefore a reliable pre-impact position could not be determined. The air intake flap had been torn off during the impact sequence which indicated that the flap was probably open and, therefore, that the carburettor heat was set to cold at impact. The front cockpit magneto switch was damaged and the selector was 180° out from any normally selectable position, while the aft cockpit magneto switch was set to '1+2' (both). The front cockpit switch panel housing the generator and battery switches had suffered a significant impact which meant that the switch positions were not reliable pre-impact positions.

Instrument examinations

The bulbs from the rear cockpit Central Warning Panel (CWP) were examined. These included bulbs which illuminate to indicate that the left and right fuel tank levels are less than 12 litres in each side, that the generator is not producing sufficient output, that the

Footnote

[20] CAA CAP 747 Generic Requirement No. 24 states that calendar limits must be observed if the aircraft is used for the purposes of Public Transport or Aerial Work. Aerial work means any purpose, other than commercial air transport or public transport, for which an aircraft is flown if valuable consideration is given or promised for the flight or the purpose of the flight. In August 2016 the term 'aerial work' was replaced with 'commercial operation' when The Air Navigation Order 2016 was introduced.

master switch is turned on, and a stall warning indication which illuminates close to the stall. The bulbs were examined under the microscope to look for indications of filament stretch. A stretched filament indicates that it was probably hot at impact and, therefore, that the light was on[21]. Both the bulbs for the master switch caption and the bulbs for the generator caption were stretched, indicating that the master switch was probably on at impact and that the generator was probably generating below normal output. According to a Yak expert, if an engine is windmilling following a loss of power, then the generator output would be sufficient to prevent this light from illuminating if the aircraft is at best glide speed. The cut-off airspeed is not known, but it is possible that near stalling speed the generator caption might illuminate if the engine had lost power. None of the remaining bulbs had stretched, indicating that the fuel level in each tank was above 12 litres and that the stall warning was probably not illuminated at the moment of impact.

The light bulbs inside the fuel gauge (Figure 8) were also examined and three of the bulbs were found to be stretched. These were for the left tank quantities 40 and 45, and for the right tank quantity 40. During transition from one indicated level to the next, the two quantities can be flickering on and off. This indicated that the left fuel tank quantity was probably between 40 and 45 litres and the right fuel tank quantity was probably about 40 litres.

Powerplant examination

One of the two propeller blades had separated at its root and broken into pieces at impact. The tip of this blade had chordwise scratches consistent with rotation. The blade which remained attached was relatively undamaged, with light chordwise scratching on its forward face near the root, but none at the tip. This evidence indicated that the propeller was rotating at impact but had stopped almost immediately, meaning that the engine was probably producing little, or no power.

A full strip examination of the engine was carried out at an approved maintenance facility by an engineer with experience of M-14P engines. Cylinders 3 and 4 (in the lower left corner) had detached, but the damage was consistent with bending failures associated with ground impact in that location. No mechanical damage was found that would explain a loss of power. Both magnetos had suffered impact damage but when tested with their respective ignition leads, the magnetos produced good steady sparks at low and high rpm. The spark plugs were in satisfactory condition.

The carburettor was too damaged to test, but a strip examination did not reveal any anomalies or defects.

The drive from the accessory gearbox to the fuel pump was checked and was intact. The fuel pump had been knocked off its mounting plate during the impact which had also caused its fuel outlet connection to break. The pump was mounted in a fuel pump test rig and at low rpm there was no fuel flow. When the rpm was increased to 1,000 rpm, the

Footnote

[21] Hot bulb filaments are more ductile than cold filaments which makes them more likely to stretch than break during a high-g impact. Cold filaments are brittle and are likely to break without any stretch.

flow started. When the rpm was subsequently reduced to 450 rpm the flow remained. The test engineer explained that the lack of initial flow was due to air in the system. The higher rpm was required to suck the air through and prime the fuel lines. At 2,200 rpm and a specified back pressure of 1.4 psi, the fuel flow exceeded the minimum requirement of 175 litres/hour by 80 litres/hour.

Fuel system examination

Both main fuel tanks were empty apart from a small trickle of fuel, while the collector tank contained 1.8 litres of fuel. Soil samples beneath the aircraft revealed the presence of fuel, although an accurate quantity could not be determined. There were sufficient impact-related breaks in the fuel lines to explain the loss of fuel from the main tanks. The fuel in the collector tank was tested and conformed to the properties of AVGAS 100LL, with no evidence of contamination.

The non-return valves and attached fuel pipe work were removed and tested with fuel. The valves operated normally with no sticking. The valves were additionally strip examined and there was no evidence of sticking. The flop-tube inside the collector tank was examined and it was free to pivot between top and bottom. The collector tank was partially filled with fuel and fuel flowed to the outlet when inverted and then righted.

The coarse and fine fuel filters were not blocked. The fuel hose at the outlet of the coarse filter was loose; it had backed off about 90° from a hand-tight position. The fitting had been wire-locked to the bolt securing the filter bowl to the firewall, but this attachment had failed in the impact so the end of the wire-locking had come free. When the end of the wire-locking was positioned in its likely pre-impact position, there was sufficient slack for the fitting to back off to the as found position, although it's possible that the wire-locking had stretched when the attachment failed. The filter bowl was filled with fuel but no fuel leaked out of the loose fitting. An additional test was carried out to see if air could be entrained through the loose fitting. A clear plastic hose was attached to the filter bowl outlet and a hand pump, while another hose was connected to the filter bowl inlet and a fuel tank. During pumping some air bubbles were seen in the outlet hose, and the amount of bubbles reduced when the outlet fitting was hand-tightened.

The spherical-shaped compensation tank had been flattened during the impact so could not be tested, but its fittings were secure.

The fuel primer handle had separated from its cockpit mounting during the impact and its three connecting fuel pipes had failed. The handle had also broken off and its position was half-way between left and neutral. When the primer is in the full left or full right position the handle needs to be pushed inwards before it can be rotated; however, when in the central position it can be rotated left or right without being pushed in which means that it can be knocked left or right from neutral. There is a knurled collar at the base of the primer handle which can be tightened to reduce leaks but also increases the resistance to pumping. The primer was tested by pumping 10 strokes in the left and right positions with the collar in the as-found position. This resulted in an average flow rates per stroke of 8.6 ml in the left position and 7.2 ml in the right position. With the collar fully tightened the flow rate increased to 9.2 ml and 9.3 ml per stroke in the left and right positions respectively.

Tests were carried out with the collar in the as-found position to see if the flow rate reduced when the pump was actuated at a high rate. When the pump was actuated in the left position 13 times in 10 seconds (1.3 strokes per second) the average flow rate was 8.2 ml per stroke. This would result in a flow rate of 38.4 litres/hour, which would be sufficient to maintain level flight given that the maximum range fuel flow[22] is 37.3 litres/hr.

Seat harness examinations

The front and rear seats were fitted with 5-point harnesses. The straps were secured using a pin and cone fitting (Figure 10). The strap ends with holes are slotted over the cone and then held together by a butterfly pin. This pin is pulled out sideways to release the straps and a short lanyard tethers the pin to the right lap strap. The front and rear seat lap straps were made of a tan linen outer layer and a nylon inner layer, which was the type of strap fitted at original manufacture. The front and rear seat crotch straps and upper portions of the shoulder straps were made of a blue nylon material which was similar to the original type used, but could not be confirmed as such. The lower portions of shoulder straps were made of the same tan linen/nylon material as the lap straps. The blue nylon straps were about 1.6 mm thick but doubled up in some areas. The tan linen/nylon straps were about 4 mm thick and consisted of 2 mm thick layers stitched together.

Figure 10

Front seat 5-point harness as found (left); all straps secured (right)

Footnote

22 The maximum range fuel flow is the fuel flow that will maximise how far the aircraft can fly. The maximum endurance fuel flow is the minimum fuel flow required to maintain level flight for as long as possible, which will be slightly less than the maximum range fuel flow quoted here. The manufacturer does not quote the maximum endurance fuel flow.

The front seat right lower shoulder strap had failed in overload at the adjustable buckle (Figure 10) and the crotch strap had failed at its lower fuselage fitting. This lower fitting failure was probably caused by distortion of the floor and seat structure which resulted in the seat pan moving forwards against the crotch strap. The front seat lap straps had not failed but the butterfly pin had come out, so the straps were no longer connected. If the butterfly pin had not been inserted at the time of impact it is unlikely that the shoulder strap or crotch strap fitting would have failed. It appeared most likely that the pin came out during the impact sequence which allowed the FSP to be thrown from his seat. There were no witness marks on the pin or on its tether to help explain how it came out.

The rear seat upper shoulder straps had both failed in overload above the adjustable buckles (Figure 11), and the rear seat left lap strap had failed at the adjustable buckle (Figure 12). The butterfly pin was also out, but one witness who attended the scene believes he removed it to help the commander out of his seat.

Figure 11

Rear seat shoulder harnesses (both failed at upper strap)

Figure 12

Rear seat left lap strap (failed at adjustable buckle)

The blue shoulder straps were significantly sun faded on their outer exposed surfaces; their inner surfaces were a much darker blue. The tan straps also appeared to be discoloured compared to what their original appearance probably would have been. Samples of the straps were subjected to characterisation using Attenuated Total Reflectance Fourier Transform Infrared (ATR-FIR) spectroscopy to determine if any chemical degradation had occurred. Minor differences in the spectra were observed when comparing some exposed surfaces to unexposed surfaces, suggesting some minor degradation had occurred, but this could not be quantified in terms of loss of strength.

Tensile strength tests were carried out on the front seat left and right lap straps. The left strap failed at 570 kgf, while the right strap failed at 460 kgf. Some strength reduction may have occurred during the impact but this could not be estimated. The fact that the lap straps had come undone in the impact would have reduced the loads they had experienced.

The shoulder straps were too short to be tested in a tensile test machine. The aircraft manufacturer could not provide a definitive strength figure for the original straps at manufacture and this type of linen/nylon strap is no longer made. One document provided related to an antiseptic and anti-mould treatment of the straps. It listed a strength of 450 kgf for a linen material that was 2 mm thick. It did not mention the nylon material or provide a strength figure for a stitched double layer. If this was the same linen material used on G-YAKB then it could possibly have had an original strength of 900 kgf or possibly more with the nylon.

A replacement strap was obtained from a company in Lithuania which maintains and overhauls Yak-52 aircraft. This new replacement strap was made of polyester and had a minimum break strength of 2,650 kgf, which is consistent with military strength requirements[23].

The civilian strength requirements are specified in terms of deceleration rate using an assumed pilot mass with static and dynamic tests, instead of tensile strength.

Survivability

The RAFCAM reviewed and reported on the FSP's post-mortem report and a summary of the injuries sustained by the commander.

The FSP wore a headset[24] provided by the commander, and the commander wore a Campbell Aero Classics hard shell flying helmet with integrated goggles. The RAFCAM report stated that had the FSP been wearing a protective helmet, it is possible that the protection afforded could have reduced the severity of his head injuries. The presence of helmet visors, if worn in the locked down position, could have provided some added protection and may have lessened the severity of the facial injuries. Similarly, a helmet's shell could have mitigated the forces causing the head injuries. However, it was difficult to determine if a helmet and visor combination could have reduced the injuries to the extent that the accident might have been survivable.

Footnote

[23] The Aircraft Crash Survival Design Guide (AD-A218 437, Vol 4) and Military Specification Seat System: Crash-Resistant, Non-Ejection, Aircrew, General Specification For (MIL-S-58095A) indicate that the minimum tensile breaking strength of webbing harnesses should be 2,721kg.

[24] A hard shell helmet was available to the students earlier in the week, but as a result of intercom difficulties it was replaced with a headset.

The commander's injuries included fractures to his facial bones, bilateral fractures to lower limbs, and fractures to his pelvis, ribs and palm of his right hand. His left eye was also seriously injured.

The FSP had similar hand injuries, but his were coupled with upper limb injuries. The fact that the commander's hand injuries were in isolation of upper limb fractures could indicate that he had his hand on the control column at the time of the impact. However, such injuries can be non-specific and so this evidence is inconclusive.

According to the RAFCAM report, it was likely that the commander's facial fractures resulted from impact with the instrument panel in the rear cockpit and that his forward flail would have been compounded by the failure of his shoulder harness straps.

The RAFCAM report also stated that it was likely that the failure of the front-seat webbing of the shoulder harness and the detachment of the anchor point of the negative-g strap, coupled with the inadvertent release of the harness's locking mechanism, would have influenced the severity of the FSP's head and face injuries. However, they could not determine conclusively if the severity of the FSP's injuries would have been lessened had the harness straps remained undamaged and the locking mechanism intact.

The type of helmet worn by the commander had been previously tested by RAFCAM. It was determined that this helmet had considerably less impact energy attenuation than the standard Mk 10 and Mk 4 series of helmets typically worn by military pilots.

Other information

Previous Yak-52 loss of power accidents and incidents

The AAIB has published previous reports on 45 Yak-52 accidents. Of these, six were fatal, and none of the fatal accidents involved a loss of power or a forced landing. Five of the 39 non-fatal accidents involved a loss of power and a forced landing. Two cases involved spark plug failures and one involved an accessory driveshaft failure. In the remaining two cases no cause of the loss of power was found. Loss of power events which do not result in an accident (ie no serious injury or no damage sustained during the forced landing) are not reported on; including those experienced by the commander of G-YAKB.

An experienced Yak pilot informed the AAIB of a loss of power he experienced in a Yak-52 in October 2016. It occurred at the top of a stall turn when the engine suddenly lost all power without prior warning. The pilot recovered from the dive and set best glide speed. The fuel pressure was normal and the propeller was windmilling at an engine rpm of about 60%. The throttle was free to move fore and aft, so he ruled out carburettor ice[25]. Because the fuel pressure was normal and stable, he asked the FSP to pump the primer with it set to the right 'cylinders' position. This did not have an immediate effect, but after some time the engine started firing and eventually began running normally. The loss of power lasted about 60 to 75 seconds and the aircraft lost about 2,000 ft of height. A

Footnote

[25] Carburettor ice is known to cause the throttle to stick with this carburettor type.

normal landing was carried out. A detailed engine and fuel system examination by an engineer did not reveal any faults that would have caused the loss of power. Whilst this loss of power remains unexplained, it provided evidence that a windmilling propeller can turn the fuel pump sufficiently fast to generate normal fuel pressure.

Operating piston engines for long periods without overhaul

In July 2009, a P56 Provost T1 (G-AWVF) with an Alvis Leonides radial piston engine suffered a mechanical failure which led to an in-flight engine fire and a fatal accident[26]. The failure was caused by a fatigue failure of a piston gudgeon pin. Corrosion pits on the inner surface of the pin were probably a contributory factor. This engine had not been overhauled in 45 years. This resulted in AAIB Safety Recommendation 2010-029, which recommended that the CAA:

> *'consider implementing calendar time limits between overhauls for Alvis Leonides series engines, and other historic aircraft engines that do not have manufacturer-recommended calendar limits.'*

The CAA responded to this recommendation by publishing Leaflet 70-80 '*Guidance Material for Ageing Engine Continuing Airworthiness*' in CAP 562 '*Civil Aircraft Airworthiness Information and Procedures*' on 31 October 2012. This leaflet states that in the absence of a manufacturer's published calendar life the engine is required to be overhauled after 20 years unless a hazard analysis for continued operation is carried out. However Leaflet 70-80 only applies to radial piston engines with power in excess of 400 hp, and therefore does not apply to the Yak-52's M-14P engine.

Maintenance requirements for seat harnesses

The Yak-52 Scheduled Servicing Manual[27] states to do the following inspection on the front and rear cockpit seat harnesses at every 50-hour and every 100-hour/Annual check: *'Inspect the belt system, check belt fastening and belts condition, lock operation'.*

The CAA's Light Aircraft Maintenance Schedule (LAMS/A/1999/Issue 2) states to inspect '*Seats, belts/harnesses, attachment, locking and release*' at 50 hours or 6 months, whichever occurs first. According to the CAA, they would expect this check on the belts to include '*wear/fraying, loose stitching, security of attachment and correct operation'*. There is no requirement to check for sun-fading or to track the age of the harnesses.

The aircraft manufacturer stated that the aircraft life was 20 years and therefore they considered the life of the seat harnesses also to be 20 years. The CAA's approved 20-year lifetime extension inspection was focussed on structural inspections and did not refer to seat harnesses.

Footnote

26 AAIB Bulletin 10/2010.
27 RGA/Yak52/Maint – 1988 R1 – January 2003

Analysis

General

The aircraft's engine failed without warning after a period of aerobatics, which included some inverted flight. Despite the FSP's attempts to restart the engine and maintain some power by pumping the primer, this was unsuccessful and a decision was taken to carry out a forced landing.

Operational aspects

The FSP did not attend the mandatory 90-minute Technical and Safety Briefing at the beginning of the QE week. His flight was brought forward with the pilots being observed in discussion for about 15 minutes before walking to the hangar where they appeared rushed. This was a short amount of time for the commander to brief the FSP on the aircraft's cockpit, delegation of duties and emergency procedures. This might have been significant, as some of the engine controls were only available in the front cockpit.

An aircraft operating on a PTF was not required to have a checklist and there was not one in the aircraft. The commander stated that he committed the aircraft's normal and emergency procedures to memory. In the absence of a thorough emergency brief the FSP was unlikely to have been able to proficiently assist with the fault diagnosis or any emergency drills. This would have been made more difficult with no checklist available.

Response to loss of engine power

The manufacturer's '*…Engine Shut Down During Flight*' checklist states: '*bring the throttle lever at about one third of stroke*' before pumping the primer handle in the left position and subsequently states: '*As soon as the engine starts running again, bring the throttle lever in take-off condition* [full power] *for 1-2 seconds*'. The '*engine failure'* checklist provided by the commander did not state anything with regards to throttle movement. The commander believed that, having exercised the throttle following the loss of power, he returned it to about 70% rpm. This was not in accordance with the manufacturer's checklist and may have been a factor that prevented the engine from restarting.

The attempted forced landing

The aircraft was at about 2,650 ft agl when the FSP transmitted "…PROBABLY GOING TO BE EH PFL ING [PRACTICE FORCED LANDING] TO A FIELD…" at 0932:06 hrs. The radar data shows that the aircraft continued on a steady heading to the east; during this time the pilots were primarily focussed on attempting to restart the engine with the expectation that they might be able to return to BD. The evidence shows that the commander committed to conducting a forced landing at 0933:29 hrs, at which time the aircraft was approximately 1,100 ft agl and travelling downwind. There were a number of suitable fields available for a forced landing into-wind and, given the commander's previous experience of forced landings in a Yak-52, a successful outcome should have been possible.

The evidence shows that, after the final radar point, the aircraft was initially flown in a westerly direction (into-wind), but this did not culminate in an into-wind landing. The position of the aircraft wreckage in the immediate vicinity of the strip and the commander's limited recollection point towards a late decision having been made to land on the strip. The fact that the landing gear was in transit is supporting evidence for this. It could not be determined whether the aircraft was flown to the north or the south of the strip. The commander's decision to land on the strip may have been influenced by having previously flown three successful forced landings, with the landing gear down, onto strips or runways.

There was about 1 minute, based on the average descent rate of 1,150 fpm, available from the time of the FSP transmitting that they were performing a forced landing into a field, to the aircraft reaching the ground. This was a short period of time to see the strip, commit to it and adjust the flight path to correctly align the aircraft with it. If the pilots had pursued the original plan to land in a field, it would have been less important to align the aircraft on a prescribed track, but more important to land into-wind. Given that the aircraft approached the strip downwind, it is likely that either the pilots' workload was too high for them to consider the wind direction, or they had incorrectly recalled it. The unserviceable heading indicator may have led to the pilot losing some degree of situational awareness, which may have contributed to the aircraft landing downwind.

A compounding factor was the commander being seated in the rear cockpit, which would have restricted his forward visibility, making it more difficult to manoeuvre the aircraft accurately at low level during the final approach to the strip. It is possible that the commander handed control to the FSP in the latter stages of the approach, but there was no definitive evidence as to who was at the controls immediately prior to the accident.

Cause of impact

The aircraft hit the ground in a steep left bank at the southern edge of the farm strip. Based on the damage and the distance travelled before coming to rest the aircraft was at low speed. The evidence from the CWP bulbs indicated that the generator light was probably on, which can occur at low speed, close to the stall. It is possible that the aircraft stalled prior to impact causing the left wing to drop, but it is equally possible that the aircraft was being manoeuvred at low speed to reach the strip with a deliberate left aileron control input in the last few seconds. The evidence from the landing gear indicated that it was probably in transit, which means that the landing gear was probably selected down using the front cockpit lever less than 15 seconds before impact.

Loss of power

The engine had suffered a complete loss of power but reportedly produced brief periods of power when the primer was pumped in the left position. The loss of power was reportedly accompanied by a loss of fuel pressure and pumping the primer in the left position caused the fuel pressure to increase. These symptoms are consistent with a fuel pump failure, but the fuel pump operated normally during a bench test and the fuel pump drive was intact. There were no disconnections in the fuel system, apart from breaks associated with impact forces. The non-return valves were tested with fuel and inspected; there was no evidence of the valves sticking that might have caused a loss of fuel pressure. All the filters in the fuel system were clear and no blockages in the fuel system were found.

The evidence from bulb filament analysis indicates that about 83 litres of fuel remained in the main tanks at the moment of impact, which is consistent with the expected fuel amount based on fuel burn estimates with full tanks on departure. The absence of fuel in the main tanks at the accident site can be explained by the breaks in the fuel lines associated with impact. The collector tank retained 1.8 litres of fuel which was tested and found to be normal for AVGAS.

A possible cause for the loss of power was that air had entered the fuel system. According to an experienced Yak engineer, the fuel pump will stop pumping fuel if sufficient air enters it. The outlet fitting of the fuel filter bowl was found to be loose and tests revealed that some air could be entrained, but it was not a significant amount. However, if sufficient air had entered the fuel system by this method, then the symptoms reported by the pilot could be explained. The fuel pressure indication would drop to zero and pumping the primer in the left position would cause the fuel pressure to momentarily increase, because the primer pump would be pushing fuel through the coarse filter to the fuel pump, which would not cause air to be entrained. It is the sucking action of the fuel pump that could have caused air to be entrained through a loose connection.

Carburettor icing was considered as a possible cause of the loss of power, but carburettor icing usually causes a gradual loss of power and rough running, neither of which were reported. Carburettor icing is also known to cause the throttle butterfly valve to freeze on the Yak-52, resulting in the throttle lever freezing; however, the pilot recalled exercising the throttle. Carburettor icing could explain a loss of power, but would not cause a loss of indicated fuel pressure.

Water in the fuel was another possibility considered. Water in the fuel can cause a sudden loss of power, but it normally occurs shortly after takeoff. The aircraft had been flown the day before and was in a hangar overnight, so the chance of water having formed in the tanks by condensation was low. In addition, water in the fuel would not cause a loss of indicated fuel pressure.

The manual pumping of the primer was reportedly at a rate of one stroke every 3 to 4 seconds, which produced brief bursts of power. The fuel primer tests revealed that such a stroke rate would not have produced sufficient power for level flight. A stroke rate of about 1.3 strokes per second would have been necessary to maintain level flight.

The cause of the loss of power could not be determined, but the reported symptoms indicated that the problem was related to the fuel system. There have been other cases of loss of engine power on Yak-52 aircraft that could not be explained.

The Yak-52 aircraft and its M-14P engine have not been certified to any international standard and so the aircraft is operated on a PTF, which potentially carries a higher risk compared to an aircraft operating on a Certificate of Airworthiness.

Survivability

RAFCAM reported that, had the FSP been wearing a protective helmet, it is possible that the protection afforded could have reduced the severity of his head injuries. However, it was difficult to determine if a helmet and visor combination could have mitigated the injuries to the extent that the accident might have been survivable for the FSP.

Seat harness condition

The seat harness lap straps were probably original and so would have been in service for 24 years, 4 years longer than that permitted by the aircraft manufacturer. When the CAA granted a 20-year lifetime extension, seat harnesses were not among the items that required replacement. The aircraft manufacturer could not provide a definitive strength figure for the original straps at manufacture, but they provided some evidence to indicate that the strap might have had an original strength in excess of 900 kgf. The right front seat lap strap had failed at 460 kgf, so it was possible that about 50% of its strength had been lost due to ageing. There is no requirement in LAMS to check for signs of ageing or to track the age of seat belts and harnesses. Therefore, it is recommended that:

Safety Recommendation 2017-021

The Civil Aviation Authority should review the maintenance requirements for seat belts and harnesses, and, if necessary, revise the maintenance requirements to ensure that seat belts and harnesses remain in a condition with an acceptable residual strength.

Engine overhaul period

The engine had not been overhauled in 24 years. This was permitted by the CAA as long as the aircraft was not used for aerial work. If the operator had requested using G-YAKB for aerial work it is not clear what calendar limits, if any, the CAA would have imposed as a condition. Although there is no evidence that the lack of engine overhaul contributed to the loss of power, operating engines without calendar limits can cause problems as was the case in the accident to the P56 Provost T1 (G-AWVF). As a result of that accident the CAA now applies a 20-year calendar limit, unless a hazard analysis can demonstrate otherwise (Leaflet 70-80); however, it only applies to engines with more than 400 hp.

The CAA have stated that they are conducting a review of engine maintenance to determine if Leaflet 70-80 should be extended to all piston engines and whether any Alternative Means (Methods) of Compliance arising from Leaflet 70-80 should be made mandatory by means of a Mandatory Permit Directive (MPD). This will also include a review of Generic Requirement No. 24 in CAP 747.

Permit to Fly

G-YAKB was operating on a PTF. The ANO allowed PTF aircraft to do aerial work without CAA permission, by way of a demonstration flight. However, this could only be done with the minimum flight crew, which would be one in a Yak-52. If additional persons were to be carried, then CAA permission would have been needed. The commander believed he was performing a demonstration flight; however, because more than the minimum flight crew was on board, permission would have been required from the CAA, but this had not been applied for.

Conclusion

The cause of the loss of engine power could not be determined, but the reported symptoms were consistent with a fuel system problem. Attempts to restart the engine were unsuccessful and the commander committed to a forced landing from about 1,100 ft agl. Although the commander's initial intention was to force land in a field, he became aware of a farm strip and probably made a late change of decision to land on the strip. This late decision, and the subsequent manoeuvres in the attempt to reach the strip, ultimately resulted in an unsuccessful forced landing and the aircraft struck the ground in a steeply left banked attitude.

AAIB Correspondence Reports

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

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

The accuracy of the information provided cannot be assured.

SERIOUS INCIDENT

Aircraft Type and Registration:	AW109SP Grand New, G-HLCM
No & Type of Engines:	2 Pratt & Whitney Canada PW207C turboshaft engines
Year of Manufacture:	2017 (Serial no: 22369)
Date & Time (UTC):	2 August 2017 at 1514 hrs
Location:	Private landing site near Clifton Dykes, Penrith, Cumbria
Type of Flight:	Commercial Air Transport (Non-Revenue)
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Main rotor blade tip cap detached
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	3,900 hours (of which 2,500 were on type) Last 90 days - 112 hours Last 28 days - 26 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

As the helicopter approached the landing site it "shuddered" and the pilot felt a vibration through the cyclic control and airframe. He was able to control the helicopter's attitude and elected to land in an adjacent field to avoid endangering persons on the ground.

After shutdown it was apparent that the tip cap of one of the main rotor blades was missing (Figure 1). The cap was not recovered.

Figure 1

Damaged main rotor blade tip (looking towards the main rotor hub)

Investigation by the manufacturer established that the tip cap had detached because of a surface preparation error that had reduced the strength of the bonded joint.

Safety actions

The manufacturer identified the main rotor blades that were potentially affected and issued Service Bulletin 109SP-116 to introduce a periodic inspection.

The EASA issued Emergency Airworthiness Directive 2017-0176-E to mandate the requirements of the Service Bulletin.

SERIOUS INCIDENT

Aircraft Type and Registration:	Cessna 402C, N618CA
No & Type of Engines:	2 Continental TSIO-520 SER piston engines
Year of Manufacture:	1981
Date & Time (UTC):	27 July 2017 at 1800 hrs
Location:	Terrance B. Lettsome International Airport, British Virgin Islands
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 1 Passengers - 7
Injuries:	Crew - None Passengers - None
Nature of Damage:	None reported
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	26 years
Commander's Flying Experience:	2,685 hours (of which 1,928 were on type) Last 90 days - 297 hours Last 28 days - 98 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was departing from Runway 07 at Terrance B Lettsome Airport in the British Virgin Islands. The pilot reported the weather to be "hot and humid", with a temperature of 31°C, good visibility, scattered clouds at 1,900 ft, and a wind of 5 kt from 130°. Due to the limited length of Runway 07, combined with the weather conditions, the pilot elected to perform a short field takeoff (intended to minimise the takeoff ground roll required).

At around 86 KIAS, the pilot noticed significant bird activity so he elected to abort the takeoff. The aircraft came to a stop, approximately 10 ft beyond the end of the paved runway surface, in the grass. There were no injuries to persons, or damage to the aircraft.

ACCIDENT

Aircraft Type and Registration:	Piper PA-23-250 Aztec, G-BCCE
No & Type of Engines:	2 Lycoming IO-540-C4B5 piston engines
Year of Manufacture:	1973 (Serial no: 27-7405282)
Date & Time (UTC):	30 June 2017 at 1542 hrs
Location:	Shoreham Airport, Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nose landing gear and forward fuselage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	8,500 hours (of which 1,000 were on type) Last 90 days - 56 hours Last 28 days - 17 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional enquiries made by the AAIB

Synopsis

The pilot landed the aircraft with the nose landing gear partially extended after attempts to lower it were unsuccessful. Both occupants were uninjured and examination established that the nose landing gear upper drag link bolt and two of the attachment lugs were broken. This prevented the nose landing gear from extending into the locked position.

History of the flight

After a training flight involving multiple landings, the aircraft returned to Shoreham where a single-engine go-around was simulated.

When the landing gear was selected down in preparation for a final landing, the cockpit indications showed that the nose leg had not locked down. ATC confirmed that the nose leg was not extended and the pilot left the circuit to work through the checklist.

Unable to resolve the problem, the pilot landed the aircraft on the grass runway. Although the aircraft suffered some damage, both occupants were uninjured and exited the aircraft using the main door.

Aircraft examination

The AAIB examined the aircraft after it had been recovered to a maintenance facility. The nose landing gear leg and drag links had already been removed.

The upper drag link attachment bolt was found to be broken and the fracture faces showed evidence of reverse bending fatigue (Figure 1). Contamination/corrosion products indicated that the fatigue had been propagating for some time.

Figure 1

Broken drag link bolt, indicating reverse bending fatigue

The upper drag link attachment lugs were distorted and both inboard lugs were cracked (Figure 2). The accumulation of dirt on the fracture faces indicated that the cracks had existed for some time.

Figure 2

Cracked and distorted drag link attachments
(remnants of the drag link bolt are still in-situ)

Aircraft history

The aircraft had accrued approximately 7,100 hours and its most recent scheduled check was an annual check in February 2017. The maintenance agency advised that the joint would have been lubricated at that time. The next 50-hour check was imminent.

There had been no recent reports of landing gear anomalies or maintenance, with the exception of repairing a nosewheel puncture.

Conclusion

The definitive failure mechanism was not established, but it was evident that the drag link attachment bolt had been exposed to cyclic loading that exceeded its capability. Failure of the inboard attachment lugs could result in 'flexing' of the drag link attachment and, therefore, excessive loading of the bolt.

The nose landing gear could not be locked down because the upper drag link had detached from the structure.

The aircraft manufacturer was informed of this occurrence.

ACCIDENT

Aircraft Type and Registration:	Europa, G-BZTH
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2002 (Serial no: PFA 247-12494)
Date & Time (UTC):	4 August 2017 at 1106 hrs
Location:	Near Parsons Barn, Long Compton, Warwickshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Forward fuselage distorted and fractured aft of firewall
Commander's Licence:	Private Pilot's Licence
Commander's Age:	72 years
Commander's Flying Experience:	802 hours (of which 661 were on type) Last 90 days - 45 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

While on a cross-country flight the engine failed due to an oil leak and the pilot made a forced landing in a field. There were ridges in the field that were not visible from the air and the aircraft was severely damaged when it hit one of these ridges.

History of the flight

The pilot was flying from Enstone to an airstrip near Gloucester in conditions of good visibility and with a westerly breeze. Approximately eight miles northwest of Enstone, at an estimated altitude of 1,900 feet agl, the engine failed and would not restart. The pilot selected a suitable field and managed to touch down at the point he aimed for.

After running along the ground a short distance, the aircraft decelerated violently and came to a halt. The pilot exited through his door and then noticed there were ground ridges which were not visible from the air. He had landed across the ridges and it was one of these that caused the deceleration and the damage to the aircraft (Figure 1).

Following recovery of the aircraft, the pilot discovered that the oil drain plug for the engine was missing and the engine had seized due to lack of lubrication.

Figure 1

The engine and forward fuselage of G-BZTH seen resting on a ridge
with the rear fuselage in a broad furrow

Prior to the flight the pilot had changed the engine oil, with assistance from a friend. The oil had been drained and the aircraft left unattended before the engine was refilled with oil, and an engine run was carried out to check the oil pressure. No oil leak was seen after the engine run, but it appears the oil plug was not refitted correctly, possibly due to some miscommunication, and it became detached during the flight, allowing the oil to escape.

ACCIDENT

Aircraft Type and Registration:	Europa, G-LEBE
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2012 (Serial no: PFA 247-12927)
Date & Time (UTC):	1 August 2017 at 1215 hrs
Location:	Popham Airfield, Hampshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Distortion of landing gear retraction lever and surround
Commander's Licence:	Private Pilot's Licence
Commander's Age:	71 years
Commander's Flying Experience:	603 hours (of which 290 were on type) Last 90 days - 12 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

G-LEBE is a mono-wheel version of the Europa; the main landing gear, the out-rigger landing gears and flaps are all linked and operated by one lever. After a local flight the pilot lowered the landing gear and flaps and made his approach with the landing gear/flap lever in the DOWN position. After touchdown the pilot heard a "bang" and realised the lever had sprung out of the DOWN position and moved towards the UP position, but it had snagged on its surround, become distorted and was stuck in a mid-position of its track. The mainwheel had retracted into the wheel-well but the aircraft came to a halt without suffering further damage.

The pilot assessed afterwards that he did not positively check that the lug to lock the landing gear/flap lever DOWN had engaged when he lowered the mainwheel.

ACCIDENT

Aircraft Type and Registration:	Midget Mustang M-1, G-CHJO
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine
Year of Manufacture:	1998 (Serial no: 1726)
Date & Time (UTC):	5 August 2017 at 1225 hrs
Location:	North Coates Airfield, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Right main landing gear leg detached, skin damage to right wing and rear fuselage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	78 years
Commander's Flying Experience:	1,996 hours (of which 93 were on type) Last 90 days - 8 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Following a firm landing, the aircraft rolled for approximately 100 m before the right main landing gear leg collapsed. The aircraft veered to the right and after it came to rest, in long grass adjacent to the runway, the pilot shutdown the engine and exited the aircraft normally. A photograph of the aircraft was taken (Figure 1) after it was moved to a grass parking area.

Figure 1

G-CHJO following failure of the right main landing gear leg

The pilot inspected the aircraft and discovered the right gear leg attachment bracket had failed near a weld. It was his view that the weld had not penetrated the metal sufficiently to achieve the required strength. He also discovered that the four attachment bolts on the bracket were only finger-tight and that they had been rotating. However, a detailed assessment of the failure was not made.

ACCIDENT

Aircraft Type and Registration:	Piper L18C Super Cub, G-BIYJ
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine
Year of Manufacture:	1951 (Serial no: 18-1000)
Date & Time (UTC):	18 July 2017 at 1007 hrs
Location:	Pilmuir Farm, Lundin Links, Leven, Fife
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Extensive
Commander's Licence:	Private Pilot's Licence
Commander's Age:	75 years
Commander's Flying Experience:	1,059 hours (of which 584 were on type) Last 90 days - 7 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot took off from the farm strip, which he has flown from for 23 years, to prepare for a skills test to revalidate his licence. He completed several circuits and manoeuvres, including a satisfactory practice of a baulked landing, before making his final approach to Runway 03. There was a north-easterly wind of approximately 6 kt and no unusual turbulence was apparent during the approach but, after touching down and rolling approximately 25 metres, the aircraft suddenly swung right. The pilot reacted by increasing power and taking off again, but he could not prevent the aircraft's right wing from striking a stationary combine harvester.

After being flipped upside down (Figure 1), the aircraft came to rest with the engine stopped and the pilot was able to turn off the electrics, undo his seat belt and escape through the door onto the upturned right wing. His assessment was that a sudden gust of wind caused the aircraft to swing right. He later discovered that, just before the accident occurred, a person spraying nearby crops experienced squally conditions which caused them to suspend their work.

Figure 1

The airstrip can be seen above the upturned fuselage and the farm vehicle is partly visible behind the tail of G-BIYJ

ACCIDENT

Aircraft Type and Registration:	Piper PA-30A Twin Comanche, N7EY
No & Type of Engines:	2 Lycoming IO-320-B1A piston engines
Year of Manufacture:	1969
Date & Time (UTC):	10 September 2017 at 1128 hrs
Location:	Farley Farm Airstrip, Hampshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to right landing gear leg and minor damage to right aileron and flap
Commander's Licence:	Private Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	1,793 hours (of which 864 were on type) Last 90 days - 42 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft landed on grass Runway 06, which had an upslope, in tailwind conditions. The pilot was not able to stop the aircraft before the end of the runway and it slid sideways into the hedge.

History of the flight

The aircraft was being flown to Farley Farm Airstrip for a scheduled maintenance inspection. The pilot departed from White Waltham in the morning and flew around the Isle of Wight before turning on course towards Farley Farm.

The single runway at Farley Farm is orientated 06/24 and has a grass surface of 760 m in length. The airfield is bounded by trees at the western end and by a hedgerow at the eastern end; the field elevation is 460 ft amsl. There is a significant downslope on Runway 24 and thus, for most conditions, takeoffs are preferred from Runway 24 and landings are preferred on Runway 06. The windsock is located close to the mid-point of the runway. The weather conditions in the days preceding the accident were frequently wet; the pilot reported the runway surface was damp and soft.

The pilot had received a surface wind report at Southampton Airport, 6 nm to the south east, of 230° at 11 kt. He was familiar with Farley Farm and on his arrival he flew a low pass overhead to check for model aircraft and to ensure that the runway was clear. He then joined the circuit for Runway 06.

The pilot reported having experienced some turbulence on the approach over the trees and touching down approximately 200 m into the runway. He applied the brakes but the aircraft did not decelerate as expected and at about 100 m before end of the runway he realised he would not stop. He attempted to ground loop the aircraft but it continued to slide ahead into the hedge. The right landing gear leg folded inwards but there were no injuries to the occupants and they were both able to vacate the aircraft unassisted.

The pilot assessed the cause of the accident as a possibly stronger than anticipated tailwind together with the damp condition of the grass, both of which would have contributed to the reduced braking performance.

The 1120 hrs METAR from Southampton Airport was: Surface wind from 230° at 15 kt, varying between 200° and 260°, visibility greater than 10 km, few cloud at 1,800 ft scattered cloud at 4,200 feet, temperature of 15°C and pressure 1001 hPa. An hour later, at 1220 hrs, the surface wind at Southampton Airport was reported as gusting to 26 kt.

In May 2005[1] there was a similar overrun accident on Runway 06 at Farley Farm whereby a tailwind was considered to have been a factor.

Footnote

[1] Published in AAIB Bulletin 7/2005 https://assets.publishing.service.gov.uk/media/5422f544e5274a1317000585/G-BYDX_07-05.pdf

ACCIDENT

Aircraft Type and Registration:	Robinson R22 Beta, G-BPNI
No & Type of Engines:	1 Lycoming O-320-B2C piston engine
Year of Manufacture:	1989 (Serial no: 948)
Date & Time (UTC):	26 June 2016 at 1447 hrs
Location:	West Calder, West Lothian
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	117 hours (of which 56 were on type) Last 90 days - 38 hours Last 28 days - 21 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot stated that he was landing the helicopter at a private site, on a concrete landing pad surrounded by grass that sloped down to the right as he approached it. Having touched down with the left skid on the concrete and the right on the grass, the right skid became caught in the grass and the helicopter rolled over. It came to rest on its side and was extensively damaged; the pilot was uninjured.

ACCIDENT

Aircraft Type and Registration:	Taylorcraft BC12D Twosome, G-BTFK
No & Type of Engines:	1 Continental Motors Corp A65-8F piston engine
Year of Manufacture:	1947 (Serial no: 10540)
Date & Time (UTC):	19 June 2017 at 1217 hrs
Location:	Near Gringley on the Hill, Nottinghamshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - None
Nature of Damage:	Engine cowling, propeller, landing gear, left wing and wing strut, tail fin, and rudder
Commander's Licence:	Light Aircraft Pilot's Licence
Commander's Age:	69 years
Commander's Flying Experience:	1,715 hours (of which 488 were on type) Last 90 days - 59 hours Last 28 days - 32 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was landing at Willow Farm, which is a privately owned grass airstrip. The pilot reported that because the runway is short, and as there was negligible headwind to assist the aircraft in stopping after landing, he intended to perform a short field landing.

The pilot reported that just prior to the runway threshold the aircraft became too low and clipped nearby farm crop. This caused the aircraft to roll forwards through 180° and land inverted on the runway.

ACCIDENT

Aircraft Type and Registration:	Vans RV-7A, G-ELVN
No & Type of Engines:	1 Lycoming YIO-360-M1B piston engine
Year of Manufacture:	2015 (Serial no: LAA 323-14930)
Date & Time (UTC):	12 August 2017 at 1325 hrs
Location:	Sywell Aerodrome, Northamptonshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Extensive
Commander's Licence:	Light Aircraft Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	88 hours (of which 43 were on type) Last 90 days - 23 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and enquiries made by the AAIB

Synopsis

The aircraft landed heavily on the nose landing gear which collapsed, the propeller struck the ground and the aircraft slid to a halt in a tail-high attitude, resting on its lower engine cowling and left wingtip. The pilot stated that he was not familiar with the aerodrome's grass landing surface and found it difficult to judge his height above the runway while landing.

History of the flight

This was the pilot's third landing on grass and his second on Runway 23 at Sywell, having first landed on the same runway earlier that day. He recalled that the surface wind was from 280º at 14 kt and that he flew a normal approach. The aircraft was positioned over the centreline of the runway, however the pilot had difficulty judging the height above the runway and landed heavily on the nose landing gear which collapsed. The propeller struck the surface and the aircraft slid to a halt resting on the lower engine cowling. Despite the tail-high attitude (Figure 1) the pilot and his passenger were able to open the canopy and escape forwards over the wing.

The pilot subsequently commented that just before touchdown he was not aware of any useful ground features in his field of vision to help him to judge his height accurately. On this 30 m wide runway the edge markings are 3 m x 1 m chalked slabs, spaced 80 m apart and slightly recessed into the ground. He said they were almost invisible just before touchdown and that the grass of the landing surface was too featureless to assist his precise judgement of the aircraft's height.

The pilot stated that his successful landing earlier that day was made a few metres from the centreline and that he used the visual aspect of the centreline markings to ascertain his height.

Figure 1

G-ELVN after the accident,
with runway centreline markings visible to the aircraft's right

Airfield

The aerodrome authority stated that the markings on Runway 23 accord with the CAA's '*Licensing of Aerodromes'* publication[1] and were re-chalked less than four months before the accident. A photograph taken after the aircraft was moved shows two ground marks made by the nose landing gear, with the gap between (Figure 2) which suggests that the aircraft landed heavily on the nose gear and then bounced. A historic photograph of the aerodrome (Figure 3), illustrates the markings on Runway 23 from the air.

Footnote

1 CAP168

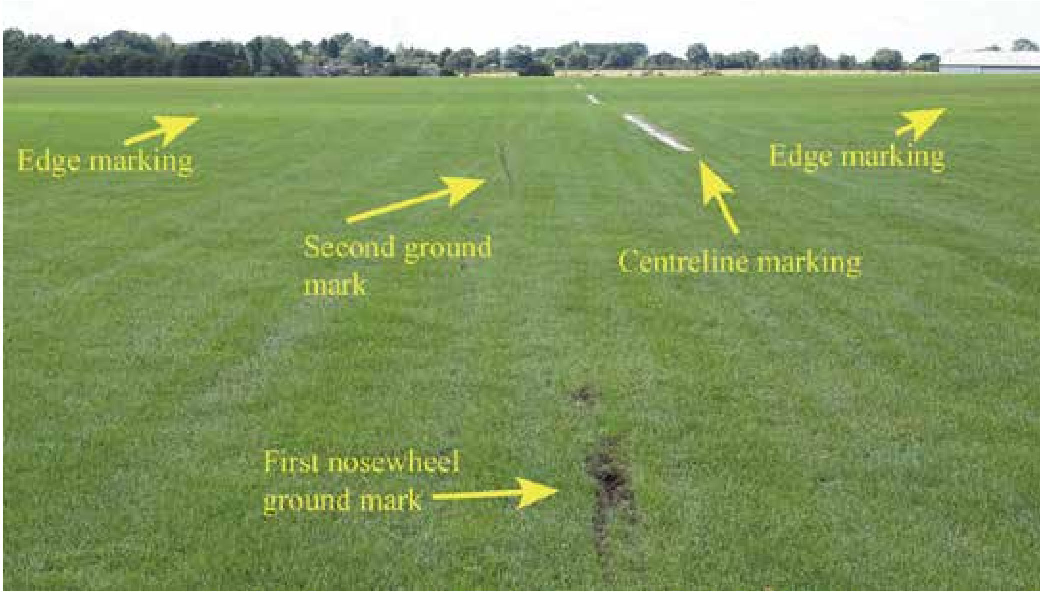

Figure 2

Marks on runway seen from eye level
(Photograph courtesy of Mr Jeff Bell)

Figure 3

Aerial photograph of Sywell Aerodrome, dated 2008, showing the Runway 23 markings
(Photograph courtesy of Mr Jeff Bell)

AAIB Comments

Reports of three previous accidents involving aircraft landing on Runway 23 at Sywell can be viewed on the AAIB's website[2], G-SYEL in AAIB Bulletin 2/2010, G-CEAM in Bulletin 11/2010 and G-CEND in 12/2014. All three accidents involved bounced landings and in each case it was suggested that the aircraft should have gone around when the pilot experienced difficulty.

The AAIB has reported on several previous accidents in which the nose landing gear leg of a Vans RV series aircraft has bent back or collapsed, many of these were on grass runways. AAIB Bulletin 3/2017 contains a report concerning G-RPRV, an RV-9A that flipped upside down, and this report lists other recorded UK accidents where the nose landing gear leg bent back. The report also mentions an 'Anti Splat kit' which is intended to reduce nose gear resonance and prevent the nose landing gear leg from tucking under. The aircraft involved in this accident was fitted with an 'Anti Splat kit'.

Footnote

2 See https://www.gov.uk/government/organisations/air-accidents-investigation-branch

ACCIDENT

Aircraft Type and Registration:	Aerotechnik EV-97 Eurostar, G-CCBK	
No & Type of Engines:	1 Rotax 912-UL piston engine	
Year of Manufacture:	2003 (Serial no: PFA 315-14025)	
Date & Time (UTC):	28 August 2017 at 1014 hrs	
Location:	Harthill Court Farm, Gloucestershire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Nosewheel bent back, damage to leading edge of both wings, propeller tips, right side flaps, and possible damage to rear spar and main landing gear mounting	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	65 years	
Commander's Flying Experience:	632 hours (of which 260 were on type) Last 90 days - 9 hours Last 28 days - 1 hour	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The aircraft was landing at a field site with an approximate landing run of 320 m available. The wind was light and the pilot judged the wind direction from a nearby wind turbine. Conditions for the approach were described as "a bit thermic" and the pilot stated that he was a "bit fast" and landed approximately 100 m into the field leaving a landing run of 220 m. The pilot believed he may have encountered a light tailwind during the landing roll and that the aircraft felt "unsettled". Concerned about a go-around due to 40 ft trees on the overrun end of the field he elected to steer towards a gap in the hedge. The aircraft stopped on top of the hedge sustaining damage to both wings, the propeller and the landing gear but the pilot was unharmed.

The POH for the aircraft quotes a braked landing distance of 260 m. This landing was made uphill, so improving the deceleration, but no factoring for this is offered in the POH. The pilot had not carried out any landing performance calculations as he used this field frequently. CAA Safety Sense leaflet 07 contains useful advice on performance planning for GA Pilots.

ACCIDENT

Aircraft Type and Registration:	Ikarus C42 FB80, G-CEAK	
No & Type of Engines:	1 Rotax 912-UL piston engine	
Year of Manufacture:	2006 (Serial no: 0606-6826)	
Date & Time (UTC):	8 July 2017 at 1130 hrs	
Location:	Ince Airfield, Merseyside	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to left landing gear, left wing strut and underside of elevator skin	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	71 years	
Commander's Flying Experience:	280 hours (of which 145 were on type) Last 90 days - 2 hours Last 28 days - 0 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The aircraft was flown from Manchester Barton Airfield to Ince Airfield, Merseyside. The pilot was familiar with Ince and made an approach to Runway 29 which is 440 m in length and 20 m in width. The final approach is across an open arable field and at the time of the accident it was growing a crop of potatoes.

The pilot noticed that an irrigation sprinkler was operating in the field to the north of the approach path but considered that it was not in the way. When the aircraft was on short final, the windscreen was suddenly sprayed with water, removing the view ahead, and the aircraft sank down short of the runway. The left main wheel caught in the crop and the left wing support strut detached. The aircraft continued rolling towards Runway 29, across a ditch, whereupon the left landing gear leg detached. The aircraft ran onto the runway surface, before coming to a stop. There were no injuries to either occupant.

The airfield operator reported that the sprinkler system had not previously been used near the airfield. They considered that it did not represent a hazard unless an aircraft was low on the approach.

ACCIDENT

Aircraft Type and Registration:	Magni M24C Orion gyrocopter, G-MSGI
No & Type of Engines:	1 Rotax 914-UL piston engine
Year of Manufacture:	2017 (Serial no: 24-16-0384)
Date & Time (UTC):	6 August 2017 at 1145 hrs
Location:	Oakley Airfield, Buckinghamshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew – 1 (Minor) Passengers - N/A
Nature of Damage:	Rotor, propeller and tail
Commander's Licence:	Private Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	300 hours (of which 59 were on type) Last 90 days - 12 hours Last 28 days - 12 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

At 50 ft above the ground, just after takeoff, the gyrocopter's engine stopped. With no further useable runway available, the pilot elected to turn slightly to the right into wind and land on a taxiway. On landing, the gyrocopter bounced before rolling onto its left side, causing damage to the rotor, propeller blades and tail. The pilot, wearing a full harness, suffered bruising and minor injuries to his legs.

Prior to the flight, the pilot had purchased some unleaded fuel which he put in a metal jerry can that he had used for a number of years. When refuelling the aircraft, he had concerns about the colour of the fuel, but convinced himself it was good after checking the flammability of a small sample. On reflection, he suspects the fuel was probably contaminated causing the engine to stop and that, during the subsequent landing, he let the airspeed drop below the recommended landing speed.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quantum 15, G-MYPY
No & Type of Engines:	1 Rotax 582-48 piston engine
Year of Manufacture:	1994 (Serial no: 6786)
Date & Time (UTC):	28 May 2017 at 1520 hrs
Location:	Friskney, Boston, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Extensive damage to airframe and engine
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	246 hours (of which 246 were on type) Last 90 days - 12 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot was returning to his home airfield at Boston in his flexwing microlight after departing from Skegness. The weather and visibility were good. The pilot reported that when he increased the throttle setting to pick up speed whilst flying straight and level at 2,300 ft, the wing failed above him. This resulted in the aircraft spiralling to the ground.

The pilot stated that he was not performing any additional control inputs at the time. However, further evidence obtained from a number of sources was consistent with the pilot attempting a stall manoeuvre. It was likely that this manoeuvre inadvertently caused the aircraft to enter a 'tumbling' departure from controlled flight, which resulted in characteristic damage to the aircraft and injuries to the pilot. The aircraft was examined by an appropriately qualified third party, who reported that no evidence of a pre-existing failure of the aircraft structure was identified.

Further information on the flight mechanics of flexwing microlight tumbling departures, and how to avoid them, will be published in a future edition of the British Microlight Aircraft Association (BMAA) magazine.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quik, G-CDLA	
No & Type of Engines:	1 Rotax 912-UL piston engine	
Year of Manufacture:	2005 (Serial no: 8102)	
Date & Time (UTC):	13 July 2017 at 1208 hrs	
Location:	Headcorn Aerodrome, Kent	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Extensive damage	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	48 years	
Commander's Flying Experience:	650 hours (of which 50 were on type) Last 90 days - 0 hours Last 28 days - 0 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The pilot, who had not flown for more than 10 months, began his takeoff run in a light and variable wind, but soon perceived the aircraft beginning to roll and drift to the right. He reacted by moving the control bar right and pushing forward on the steering bar with his right foot. However, the roll to the right developed further and, when the aircraft suddenly veered further right, the pilot realised he was losing control. The right wing struck the ground, the aircraft departed the runway and the engine stopped when the propeller impacted the keel tube. The aircraft came to rest on a taxiway and the pilot turned the magnetos off before unstrapping and exiting.

The pilot has subsequently assessed that his initial movement of the control bar was not sufficiently positive to counteract the right roll. Then, as the turn to the right turn developed, he may have instinctively reverted to the technique for steering a conventional aircraft and pushed with his left foot, so accentuating the right turn. He knew he needed to regain flying currency and now realises he should have followed guidance from the Quik Operator's Manual that pilots who have not flown for three months undertake a refresher flight with an instructor.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quik, G-FLEX
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2003 (Serial no: 7953)
Date & Time (UTC):	14 May 2017 at 1415 hrs
Location:	Winscott Barton Flying Club, Bideford, Devon
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Minor) Passengers - 1 (Minor)
Nature of Damage:	Damage to pod, nosewheel, right wing and propeller
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	478 hours (of which 478 were on type) Last 90 days - 5 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During the flare to land, the aircraft was struck by a strong gust of wind which caused the aircraft to pitch forward and flip inverted.

History of the flight

The pilot was operating from his usual field at Winscott Barton Farm from where he had been flying for 13 years. There were no marked runways but he had taken off in the direction of about 270° with a 13 kt headwind. After a one-hour scenic flight he returned to the field and noticed that the wind sock was indicating about 240° at 13 to 18 kt. On a final approach track of 270°, at about 300 ft agl, the aircraft encountered "some noticeable turbulence" so the pilot decided to go around. As he turned downwind he noticed an alternative landing site in a nearby field, which had newly cut grass and was square, but it was smaller than desired with a passenger on-board so he decided to make one more attempt at his usual field, and to divert if conditions were the same.

On this approach the pilot adjusted his angle slightly to be more into wind, about 260°, and this time it felt smoother. As he flared at about 10 ft the aircraft was hit by what the pilot described as a "strong downward force" which caused the aircraft to pitch forward uncontrollably. The nosewheel struck the ground and the aircraft flipped inverted onto its right wing, coming to rest within 15 m.

The pilot undid his lap strap and assisted his passenger with her harness and then both exited the aircraft.

The pilot's assessment of the cause

The pilot stated that he had not encountered problems before in similar wind conditions. On this occasion he believes that a particularly strong gust from the south-west caused rotor from the brow of a hill where the field drops away quite steeply. The gust struck him at a critical point on landing which he did not believe was recoverable.

ACCIDENT

Aircraft Type and Registration:	Rotorsport UK Cavalon, G-GERN
No & Type of Engines:	1 Rotax 914UL-01 piston engine
Year of Manufacture:	2016 (Serial no: RSUK/CVLN/020)
Date & Time (UTC):	18 June 2017 at 1201 hrs
Location:	Stoke Microlight Airfield, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Substantial
Commander's Licence:	Private Pilot's Licence (G and M)
Commander's Age:	48 years
Commander's Flying Experience:	504 hours (of which 84 were on type) Last 90 days - 28 hours Last 28 days - 13 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Following a normal takeoff and having reached an estimated height of 120 ft to 150 ft, the pilot noticed a sudden loss of height and airspeed. He made a forced landing onto a nearby mud bank; on touchdown the rotor blades contacted a boat and the gyroplane rolled over. The weather was warm with the potential to adversely affect takeoff performance.

History of the flight

The gyroplane was parked overnight between two polytunnel hangars at Stoke Microlight Airfield, Kent. On the day of the accident the pilot planned a flight with a passenger to Little Gransden Airfield, Bedfordshire. They arrived at the airfield late morning and the pilot prepared the gyroplane for flight. He dipped the fuel tank and confirmed there was 35 litres of fuel on board remaining from a flight the previous day. It was an unusually warm day in southern England with ambient temperatures in excess of 30°C recorded in some areas. During the pre-flight checks the pilot observed the on-board temperature gauge was indicating 35.5°C.

On completion of all of the pre-flight checks the pilot started the engine, checked the radio was working and taxied to the holding area for Runway 24. The pilot and the passenger were both wearing Active Noise Reduction (ANR) headsets.

After waiting at the holding point for other aircraft to depart the pilot lined up, pre-rotated the rotor to 220 rpm, set full power and started the takeoff. Everything appeared normal as the gyroplane lifted off and climbed to a height approaching the end of the runway that he estimated was 120 ft to 150 ft aal.

The pilot then noticed a sudden and rapid loss of height with a decreasing airspeed. He rejected the option of lowering the nose to accelerate, because there was insufficient height and decided to land immediately on an area of tidal mud bank between two mooring jetties.

The gyroplane landed upright but the rotor blades struck a moored boat and the aircraft tipped over into the mud. The pilot and his passenger, who were wearing full four-point harnesses, but not helmets, were able to release themselves from the aircraft and did not sustain any significant injury. The aircraft was recovered before it was covered by the incoming tide.

Airfield information

Stoke Microlight Airfield has a single grass runway orientated 06/24, 475 m in length by 20 m in width. The options for a forced landing immediately after takeoff from Runway 24 are limited. A railway line and overhead power lines run parallel to the runway to the north of the airfield and to the south and west is the River Medway estuary with various obstructions. If the tide is out an area of mud flats is exposed to the south.

Aircraft information

The Rotorsport Cavalon is a closed cockpit gyroplane with two side by side seats. The pilot's seat is on the right hand side; this aircraft was fitted with dual controls. The takeoff technique advised in the Flight Manual requires the nosewheel to be held off the ground until lift off and then acceleration in level flight above the runway until climb speed is attained.

G-GERN was fitted with a Rotax 914 UL engine for which the preferred fuel grades are AvGas UL91, MOGAS EN 228 Super or EN228 Super plus. An alternative fuel is AvGas 100LL. The fuel system comprises twin linked main tanks with a total capacity of 100 litres. Two electrical fuel pumps are situated inside the fuel tanks and supply fuel to a pressure regulator from where any excess fuel is returned into the fuel tanks.

The pitch setting of the propeller was checked after the accident and found to be correctly set in full fine pitch. The engine was fitted with a datalogger which recorded engine rpm once a minute; the last recorded data point in the log indicated 5,714 rpm.

The Maximum Authorised Takeoff Weight for G-GERN is 560 kg. The weight and balance data supplied by the pilot indicated the actual takeoff weight was approximately 535 kg. Performance data for a Cavalon 914 UL at 560 kg under standard atmospheric conditions and at sea level are available in the Flight Manual. At an ambient temperature of 28°C a 21% increment is added to the takeoff distance and a 20% decrement to the climb performance.

The required takeoff distance to reach a height of 15 m (50 ft) at 560 kg at sea level and 28°C was calculated as 714 m.

Other information

CAA publication '*Handling Sense Leaflet 4, Gyroplane Handling and Performance'* identifies three main areas where it is considered that better education of pilots could significantly improve the safety record for gyroplanes. The first of these is:

> *'Understanding of the take-off performance of the gyroplane in the conditions for the day.'*

The publication also notes:

> *'Bringing the stick back without sufficient airspeed will simply increase the rotor drag and even with 100% engine power the gyroplane will descend, nose high, to the ground.'*

Analysis

The pilot in his report suggested several potential reasons for the apparent loss of performance; these included a possible vapour lock in the fuel system or atmospheric conditions causing an area of sinking air.

The weather was warm and the parking position between the two polytunnel hangars would have created a local heating effect and raised the temperature of the fuel. The pilot did not notice a reduction in engine power, although it is possible that an ANR headset could mask a change in engine note. The design of the fuel system should mitigate against vapour lock, even in very warm conditions, so this appeared a less likely scenario.

The ground roll of a gyroplane is relatively short but before a climb can be initiated it must be accelerated in ground effect to attain climb speed. This acceleration phase may use significantly more distance than the takeoff roll. In this case, the calculated takeoff performance for a gyroplane at maximum TOW suggests that the takeoff distance required by G-GERN (which was only 25 kg below MTOW) would have taken the gyroplane well beyond the end of Runway 24.

Gyroplanes are vulnerable to any loss of airspeed in the after-takeoff phase and it is possible that an atmospheric disturbance could have caused a loss of airspeed. However, it seems more probable that the length of Runway 24, and the very warm ambient conditions, meant that there was insufficient distance to accelerate to and maintain an effective climb speed. Any attempt at a premature climb will result in high rotor drag and loss of airspeed.

On recognising the loss of climb performance, the pilot made a rapid decision to land on an area of raised mud flat to his left. The gyroplane was damaged but the occupants were able to escape without serious injury.

Conclusion

The aircraft suffered a loss of climb performance shortly after takeoff probably as a result of a higher air temperature and shorter field length than the pilot was accustomed to. The pilot, with limited options available, decided to make a forced landing onto the shore.

Miscellaneous

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

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

BULLETIN CORRECTION

Aircraft Type and Registration:	Piper PA-28-161 Cherokee Warrior II, G-BSBA
Date & Time (UTC):	17 August 2017 at 1230 hrs
Location:	Sandown Airfield, Isle of Wight
Information Source:	Aircraft Accident Report Form submitted by the pilot

AAIB Bulletin No 10/2017, page 85 refers

Prior to publication online, the final three sentences of this report were amended to read:

> The aircraft did not climb and veered to the left, departing the left side of the runway. It did not respond to attempts to bring it back towards the runway. At this point the passenger in the right front seat, who was also a pilot, took control and manoeuvred the aircraft onto the adjacent taxiway where it was brought to a stop after striking a wire fence and wooden post.

This amendment was in order to provide clarification as to when the other aircraft occupant took control.

BULLETIN CORRECTION

Aircraft Type and Registration:	Robin DR400/180 Regent, G-ETIV
Date & Time (UTC):	7 December 2016 at 1327 hrs
Location:	Rochester Airport, Kent
Information Source:	AAIB enquiries in response to a report from Rochester Airport

AAIB Bulletin No 7/2017, page 63 refers

Following publication of the report, further clarification was received from the Civil Aviation Authority relating to the recording of the flight in the pilot's log book. The final paragraph of the section headed '*Flight Instructors*' has been amended and the text should read:

> The pilot in command of a single pilot aircraft who flies alone or with passengers is responsible for the safe conduct of the flight and logs the time as PIC. However, when accompanied by an FI, exercising the privileges of an FI certificate, the pilot should log the flights as *'pilot under training'* or '*dual instruction time'*. There are exceptions to this, such as when a student pilot on an integrated course receives instrument training and the FI does not control the aircraft for any part of the flight; they may then certify the pilot's log book to state they acted as *'student pilot-in-command (SPIC)'*. Also when a pilot successfully undertakes a flight test in a single pilot aircraft with an EASA or CAA Authorised Examiner they are entitled to log the time as '*pilot-in-command under supervision (PICUS)'*.

The online version of this report was corrected when published on 2 October 2017.

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

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

Published November 2011.

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

Published February 2014.

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

Published June 2014.

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

Published September 2014.

1/2015 Airbus A319-131, G-EUOE
London Heathrow Airport
on 24 May 2013.

Published July 2015.

2/2015 Boeing B787-8, ET-AOP
London Heathrow Airport
on 12 July 2013.

Published August 2015.

3/2015 Eurocopter (Deutschland) EC135 T2+, G-SPAO
Glasgow City Centre, Scotland
on 29 November 2013.

Published October 2015.

1/2016 AS332 L2 Super Puma, G-WNSB
on approach to Sumburgh Airport
on 23 August 2013.

Published March 2016.

2/2016 Saab 2000, G-LGNO
approximately 7 nm east of Sumburgh Airport, Shetland
on 15 December 2014.

Published September 2016.

1/2017 Hawker Hunter T7, G-BXFI
near Shoreham Airport
on 22 August 2015.

Published March 2017.

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

http://www.aaib.gov.uk

GLOSSARY OF ABBREVIATIONS

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

Air Accidents Investigation Branch