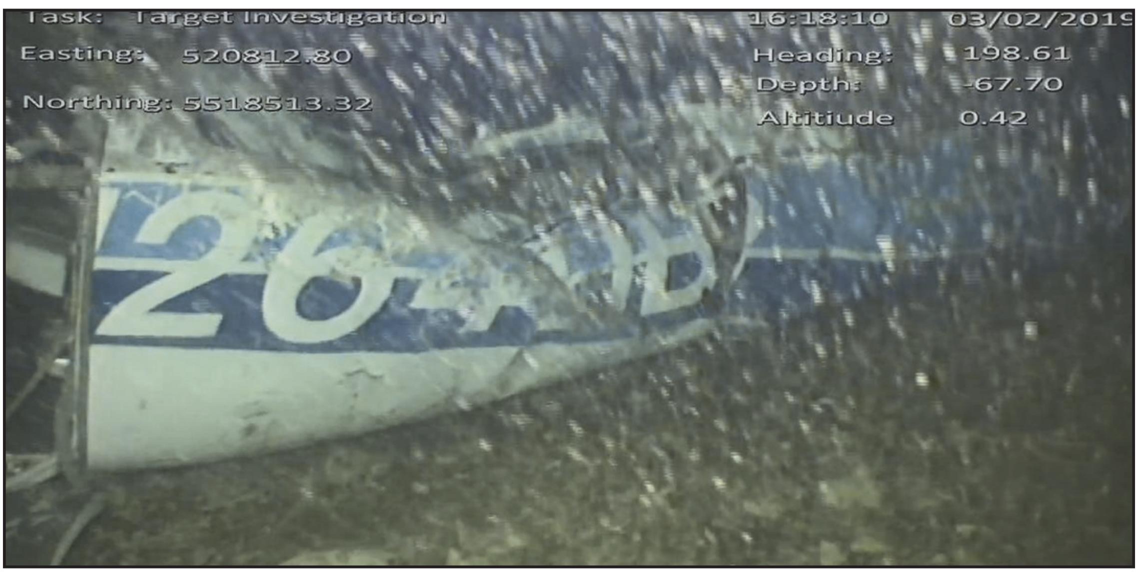
AIRCRAFT ACCIDENT REPORT 1/2020

AAIB
Air Accidents Investigation Branch

Report on the accident to
Piper PA-46-310P Malibu, N264DB
22 nm north-north-west of Guernsey
on 21 January 2019



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This investigation has been conducted in accordance with
Annex 13 to the ICAO Convention on International Civil Aviation,
EU Regulation No 996/2010 and
The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018.

The sole objective of the investigation of an accident or incident under these Regulations is the prevention of future accidents and incidents. It is not the purpose of such an investigation to apportion blame or liability.

Accordingly, it is inappropriate that AAIB reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

Published 13 March 2020

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Contents

Appendices

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

14 CFR	Title 14 of the Code of Federal Regulations
AAIB	Air Accidents Investigation Branch
A&P	Aircraft and Propulsion
AD	Airworthiness Directive
AMC	Acceptable Means of Compliance
amsl	above mean sea level
aal	above airfield level
AOC	Air Operator's Certificate
ARA	Authority Requirements for Aircrew
ATC	Air Traffic Control
CAA	Civil Aviation Authority
CAP	CAA publication
CB	Cumulonimbus
CWS	Control Wheel Steering
CO	Carbon Monoxide
COHb	Carboxyhaemoglobin
CS	Certification Specification
CS-STAN	Certification Standard
BEA	Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile
EASA	European Union Aviation Safety Agency
ELT	Emergency Locator Transmitter
ETSO	European Technical Standards Order
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FCL	Flight Crew Licensing
F.S.	Fuselage Station
fpm	Feet per minute
g	Acceleration due to gravity
GA	General Aviation
gal	Gallon
GPS	Global Positioning System
hPa	Hecto-Pascal
hrs	Hours
IA	Inspector Authorization
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
IR	Instrument Rating
IR(R)	Instrument Rating (Restricted)
JIAAC	Junta de Investigación de Accidentes de Aviación Civil
KIAS	Knots Indicated Airspeed
LOC	Loss of Control
m	Metres
MMEL	Master Minimum Equipment List
nm	Nautical miles
NTSB	National Transportation Safety Board
PIC	Pilot-in-Command
PPL	Private Pilot's Licence
ppm	parts per million
psi	pounds per square inch
ROV	Remotely Operated Vehicle
rpm	Revolutions per minute
SAIB	Special Airworthiness Information Bulletin
SALMO	Ministry of Defence Salvage and Marine Operations Project Team
SB	Service Bulletin
sec	Second
SEP	Single Engine Piston
SIB	Safety Information Bulletin
TC	Transport Canada
TIT	Turbine Inlet Temperature
TSO	Technical Standards Order
UTC	Coordinated Universal Time
V_A	Design manoeuvring speed
V_{NE}	Never-exceed speed
V_{NO}	Maximum speed in normal operation
V_S	Stall speed
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
W.S.	Wing Station

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Air Accidents Investigation Branch

Aircraft Accident Report No:	1/2020 (EW/C2019/01/03)
Registered Owner:	Southern Aircraft Consultancy Inc.
Operator:	Private owner[1]
Aircraft Type:	Piper PA-46-310P Malibu
Nationality:	United States of America
Registration:	N264DB
Place of Accident:	22 nm north-north-west of Guernsey
Date and Time:	21 January 2019 at 2016 hrs (all times in this report are UTC unless stated otherwise)

Summary

The Air Accidents Investigation Branch (AAIB) became aware on 21 January 2019 at 2122 hrs that the aircraft had gone missing at approximately 2016 hrs. The search for survivors, coordinated by the authorities in Guernsey, was called off at 1515 hrs on 24 January 2019.

The aircraft was lost in international waters and, in such circumstances, Annex 13 to the Convention on International Civil Aviation places a responsibility on the State of Registration of the aircraft, in this case the USA as represented by the National Transportation Safety Board (NTSB), to commence an investigation. However, the State of Registration may, by mutual agreement, delegate the investigation to another State. On 22 January 2019, in anticipation that an accident investigation would be required, the NTSB delegated responsibility for the investigation to the State of the Operator, in this case the UK as represented by the AAIB.

In exercise of his powers, the Chief Inspector of Air Accidents ordered an investigation to be carried out in accordance with the provisions of Regulation (EU) 996/2010 and the UK Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018. The sole objective of the investigation of an accident or incident under these Regulations is the prevention of accidents and incidents. It shall not be the purpose of such an investigation to apportion blame or liability.

1 Ownership through a UK Limited company.

In accordance with established international arrangements, both the NTSB, representing the State of Design and Manufacture of the aircraft, and the Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA) in France, which had been supporting search activities, appointed Accredited Representatives to the investigation. The Junta de Investigación de Accidentes de Aviación Civil (JIAAC) in Argentina, representing the State of Nationality of the passenger, appointed an Expert. The European Union Aviation Safety Agency (EASA) and UK Civil Aviation Authority (CAA) assisted the investigation, and the NTSB was assisted by Advisors from the aircraft and engine manufacturers.

Prior to this Final Report, the AAIB published Special Bulletins on 25 February 2019[2] and 14 August 2019[3].

The investigation established that the aircraft departed from Nantes Airport, France, at 1906 hrs on 21 January 2019 carrying a passenger on a commercial basis to Cardiff Airport in the UK. At 2016 hrs, probably while manoeuvring to avoid poor weather, the aircraft was lost from radar and struck the sea 22 nm north-north-west of Guernsey. Neither the pilot nor aircraft had the required licences or permissions to operate commercially.

The investigation identified the following causal factors:

1. The pilot lost control of the aircraft during a manually-flown turn, which was probably initiated to remain in or regain Visual Meteorological Conditions (VMC).

2. The aircraft subsequently suffered an in-flight break-up while manoeuvring at an airspeed significantly in excess of its design manoeuvring speed.

3. The pilot was probably affected by carbon monoxide (CO) poisoning.

The investigation identified the following contributory factors:

1. A loss of control was made more likely because the flight was not conducted in accordance with safety standards applicable to commercial operations. This manifested itself in the flight being operated under Visual Flight Rules (VFR) at night in poor weather conditions despite the pilot having no training in night flying and a lack of recent practice in instrument flying.

2. In-service inspections of exhaust systems do not eliminate the risk of CO poisoning.

2 https://assets.publishing.service.gov.uk/media/5c73c02bed915d4a3d3b2407/S1-2019_N264DB_Final.pdf [accessed February 2020]

3 https://assets.publishing.service.gov.uk/media/5d53ea15e5274a42d19b6c2e/AAIB_S2-2019_N264DB.pdf [accessed February 2020]

3. There was no CO detector with an active warning in the aircraft which might have alerted the pilot to the presence of CO in time for him to take mitigating action.

Safety action was taken to: raise awareness of the risk associated with unlicensed charter flights; and improve the guidance given to personnel undertaking inspections of exhaust systems.

Five Safety Recommendations have been made in this report concerning: flight crew licensing records; the carriage of CO detectors; and additional in-service inspections of exhaust systems.

1. Factual information

1.1 History of the flight

The pilot of N264DB flew the aircraft and the passenger from Cardiff Airport to Nantes Airport on 19 January 2019 with a return flight scheduled for 21 January 2019. The pilot arrived at the airport in Nantes at 1246 hrs on 21 January to refuel and prepare the aircraft for the flight. At 1836 hrs the passenger arrived at airport security, and the aircraft taxied out for departure at 1906 hrs with the passenger sitting in one of the rear, forward-facing passenger seats. Figure 1 shows the aircraft on the ground before departure.

Figure 1

N264DB on the ground at Nantes prior to the flight

The pilot's planned route would take the aircraft on an almost direct track from Nantes to Cardiff, flying overhead Guernsey en route (Figure 2). The Visual Flight Rules (VFR) flight plan indicated a planned cruise altitude of 6,000 ft amsl and distance of 265 nm.

Figure 2

Planned route from Nantes to Cardiff

The aircraft took off from Runway 03 at Nantes Airport at 1915 hrs, and the pilot asked Air Traffic Control (ATC) for clearance to climb to 5,500 ft. The climb was approved by Nantes Approach Control and the flight plan was activated.

The aircraft flew on its planned route towards Cardiff until it was approximately 13 nm south of Guernsey when the pilot requested and was given a descent clearance to remain in Visual Meteorological Conditions (VMC)[1]. Figure 3 shows the aircraft's subsequent track. The last radio contact with the aircraft was with Jersey ATC at 2012 hrs, when the pilot asked for a further descent. The aircraft's last recorded secondary radar point was at 2016:34 hrs, although two further primary returns were recorded after this[2].

The pilot made no distress call that was recorded by ATC.

1 Pilots must remain in VMC to continue flight under VFR, the rules under which this flight was undertaken. The aircraft was in Class D airspace and so the pilot was required to remain 1,500 m horizontally and 1,000 ft vertically clear of cloud, and have an in-flight visibility greater than 5,000 m.

2 See section 1.11, *Recorded information*, for an explanation of the radar data.

Figure 3

Aircraft track in the vicinity of Guernsey

1.2 Injuries to persons

Injuries	Crew	Passengers	Other
Fatal		1	
Missing	1		
Serious			
Minor/None			

The pilot's body was not recovered. The accident was not considered to be survivable.

1.3 Damage to the aircraft

The aircraft was destroyed.

1.4 Other damage

There was no other damage.

Factual Information

1.5 Personnel information

1.5.1 Pilot

Age:	59 years
Licence:	FAA Private Pilot's Licence
	EASA Private Pilot's Licence
Flying Experience:	
Total on all types:	Approximately 3,500 hours
Total on type:	Approximately 30 hours
Last 24 hours	0 hours
Last 7 days:	Approximately 3 hours
Last 90 days:	Approximately 20 hours

The pilot did not fly between arriving at Nantes on 19 January 2019 and departing on the accident flight and was therefore considered to be well-rested.

1.5.2 Pilot's licence

The pilot of N264DB held an EASA Private Pilot's Licence (PPL), issued by the CAA, and a Federal Aviation Administration (FAA) PPL, issued based on his EASA PPL[3]. He held a valid Instrument Rating (Restricted) (IR(R))[4] on his UK EASA licence but no Night Rating.

An EASA Single Engine Piston (SEP) Rating is valid for 24 months and can be renewed either by completing a proficiency check with an examiner or by experience[5]. The accident pilot's SEP rating was due to expire in November 2018 and the investigation found no record of it being renewed.

The pilot had undertaken EASA 'differences training' to enable him to fly PA-46 aircraft using an SEP Rating. Images of his logbook stored on a computer showed that, following the training, he had been authorised in error to fly the PA-46 as pilot-in-command (PIC) during both the day and night. It was not established whether the pilot had undertaken the FAA's equivalent 'complex aircraft training' for the PA-46.

The FAA requires that pilots complete a 'Flight Review' with an authorised instructor or examiner every 24 months in order to maintain the validity of

3 See section 1.17.3, *Flight crew licensing requirements.*
4 The IR(R) is a UK-only instrument qualification, that permits the holder to operate a single-pilot, single or multi engine, non-complex, non-high performance aeroplane under IFR except in Class A Airspace.
5 Renewing by experience requires the pilot to have completed in the 12 months before the rating expiry date: at least 12 hours of flying in aircraft of the relevant class of which at least 6 hours must be as pilot-in-command; 12 takeoffs and landings; and a training flight of at least an hour with an instructor or examiner. EASA Part FCL.740.

their licence[6]. The accident pilot had completed a flight review in the previous 24 months.

A PPL, whether issued by EASA or the FAA, does not allow a pilot to carry passengers for reward; to do so requires a commercial licence. The pilot did not have a commercial licence and was not operating under the provisions of an Air Operator's Certificate (AOC)[7].

1.5.3 Colour vision deficiency

At his initial medical in 2001, it was identified that the pilot had colour vision deficiency (CVD) and a restriction was placed on his CAA-issued medical certificate. In 2012, the pilot underwent more detailed tests which showed he had mild-to-moderate protan deficiency, which meant that the receptors in his retinas were less sensitive to light in the red wavelengths. The pilot's colour vision was sufficient to pass these more detailed tests as 'colour safe' for the purposes of flying and the restriction was removed. CVD has no effect on night vision.

At the time of the accident, there was no restriction on his licence or medical certificate which would have prevented him from completing the required training for a night rating and holding such a qualification. However, the investigation found no evidence of the pilot completing any night flying training.

1.5.4 Pilot's recent flying experience

Evidence from previous logbooks and from witnesses showed that the pilot gained a large percentage of his flying experience dropping parachutists from single and twin-engine aircraft. He had little experience of flying in Instrument Meteorological Conditions (IMC) or operating under Instrument Flight Rules (IFR)[8]. The pilot last renewed his IR(R) in May 2017, which meant the rating was valid at the time of the accident. All his recorded flying since the renewal had been recorded as single pilot operating under VFR, so it was unlikely he had practised much instrument flying since then.

The pilot began flying N264DB in June 2018. He flew it and another similar type regularly around the UK and Europe. The pilot's records showed that he had been paid a fee for flights on numerous occasions. Other evidence showed that he was to be paid a fee for the accident flight.

Although the pilot did not hold a Night Rating, his records indicated that he had flown several flights at night over the preceding 12 months.

6 Title 14 of the Code of Federal Regulations Part 61.56.
7 Air Operators Certificate – a certificate authorising an operator to carry out specific commercial operations.
8 See Footnote 2. If a flight cannot remain within VMC, the aircraft will, by definition, be flying in IMC and the pilot must operate under IFR.

1.6 Aircraft information

1.6.1 Leading particulars

Manufacturer:	Piper Aircraft, Inc
Type:	PA-46-310P Malibu
Engines:	One Teledyne Continental TSIO-520-BE
Date of manufacture:	1984
Airworthiness Certificate:	27 April 1984
Last maintenance check:	Annual / 100-hour 30 November 2018
Total airframe hours:	6,636 hours on 30 November 2018
Maximum takeoff weight:	4,100 lbs
Takeoff weight (actual):	Not known

1.6.2 General description of the aircraft

The PA-46 is produced in several versions two of which are: the PA-46-310P (Malibu) equipped with a Teledyne Continental TSIO-520-BE engine rated at 310 hp; and the PA-46-350P (Malibu Mirage) equipped with a Textron Lycoming TI0-540-AE2A engine rated at 350 hp. The aircraft was designed and initially certified under the provisions of Title 14 of the Code of Federal Regulations (14 CFR) Part 23[9]. The Type Certificate for the PA-46-310P was approved on 27 September 1983.

The PA-46-310P (Malibu) is a single engine, all-metal airframe, low wing, pressurised aircraft certified for flight up to 25,000 ft. It is fitted with retractable landing gear and a turbocharged piston engine driving a two-blade constant speed propeller. The primary flight controls are conventional in operation and the control surfaces are operated by the pilot's control wheel and rudder pedals through a system of cables and pullies. The aircraft has a fuel capacity of 122 gal (US), stored in an integral fuel tank located in each wing, of which 120 gal (US) is useable. A forward baggage compartment is located between the engine firewall and forward pressure bulkhead.

Hydraulic pressure is supplied by an electric motor-driven pump assembly installed in the aft portion of the aircraft cabin, inside the pressure bulkhead. The undercarriage is held in the retracted position by hydraulic pressure and, if the pressure drops below a minimum level, a pressure switch automatically energises the pump to restore the pressure.

9 14 CFR Part 23 – *Airworthiness Standards: Normal Category Airplanes*.

N264DB was equipped with two alternators, four-position hydraulically operated flaps, an electrically heated stall warning device and an electrically heated pitot probe. It was also equipped with an ice protection system that allowed it to fly into known icing conditions, and avionics equipment that allowed it to be flown at night in IMC.

1.6.3 Engine information

1.6.3.1 General description of the engine

The TSIO-520-BE is a fuel-injected, twin-turbocharged, air-cooled, horizontally-opposed, six-cylinder engine. The engine oil is cooled by ram air[10] passing through the oil cooler fitted on the rear of the engine. Oil is distributed throughout the engine to provide lubrication and cooling, and to operate the propeller governor. Engine crankcase gasses are discharged through an air / oil separator located behind the oil cooler and vented out of the left exhaust stack.

The purpose of the turbochargers is to maintain a desired manifold air pressure at a given throttle setting regardless of varying conditions of ambient air temperature and pressure. Air from the turbocharger compressor is cooled in the intercooler before entering the manifold air distribution system mounted on top of the engine where it is distributed to the cylinder intake ports (Figure 4).

The turbocharger consists of a compressor driven by a turbine, both of which are mounted on a single shaft supported by bearings lubricated by the engine oil system. Labyrinth seals prevent the engine oil leaking along the shaft into the compressor or turbine.

The exhaust system, which on N264DB was made from stainless steel, consists of a right and left exhaust tailpipe, each connected to its respective turbocharger. Exhaust gasses from the left and right side of the engine are connected to a common duct which bypasses the turbochargers and directs gas through a wastegate into the left tailpipe (Figure 4). The purpose of the wastegate is to control the speed of the turbines by directing excess exhaust gas away from them.

10 Ram air: air 'rammed' into the engine through a forward-facing inlet. 'Ram' refers to the increase in air pressure as a result of the aircraft speed through the atmosphere.

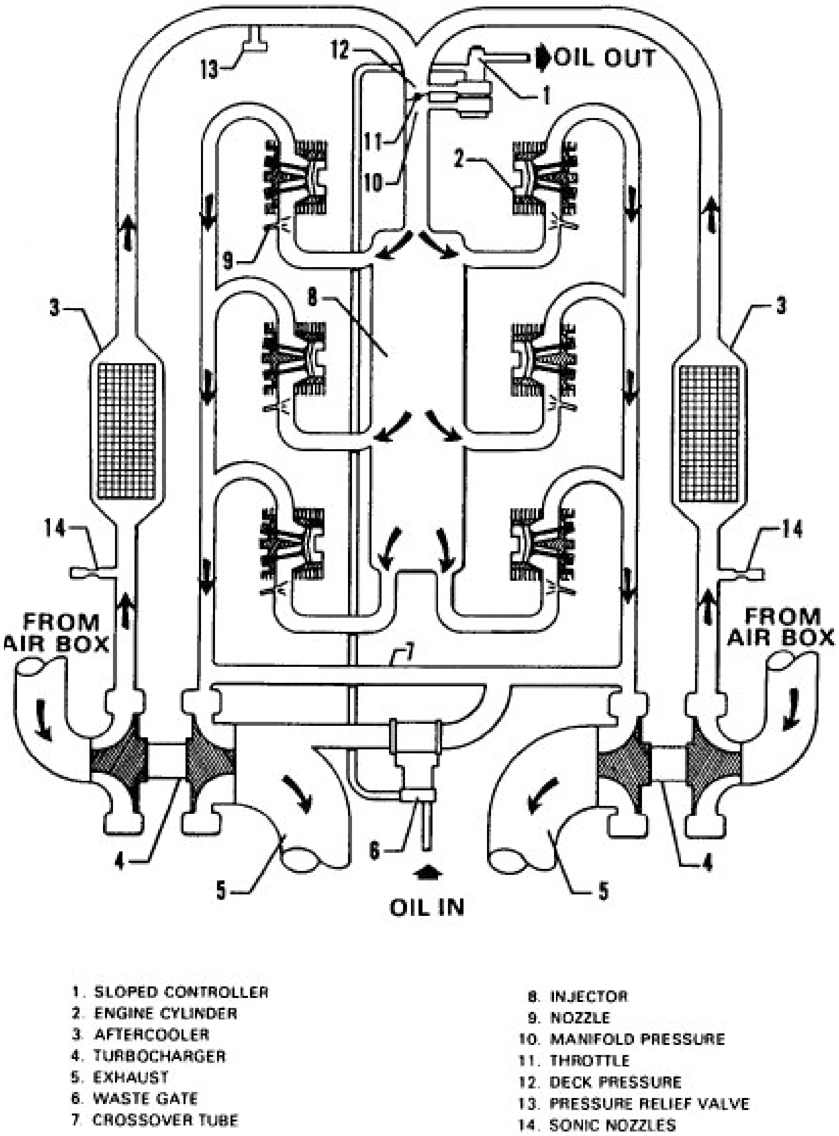

Figure 4

Engine induction and exhaust system

A heater muff is attached via spot welds to the right exhaust tailpipe. Ram air ducting and a removable shroud are placed over the heater muff to provide hot air for cabin conditioning (Figure 5). The shroud is secured in place by four fasteners. Figure 6 shows another tailpipe from a PA-46-310P aircraft with the shroud unfastened and slid to the end of the tailpipe to allow it to be inspected. The ‘*heated ram air out’* and ‘*exhaust gas in’* ducts are spot welded and brazed onto the tailpipe and covered with a fixed cover.

In Figures 5 and 6 the red arrows show the flow of exhaust gas through the tailpipe. The yellow arrows show ambient ram air, which flows in the space between the tailpipe and the heater muff.

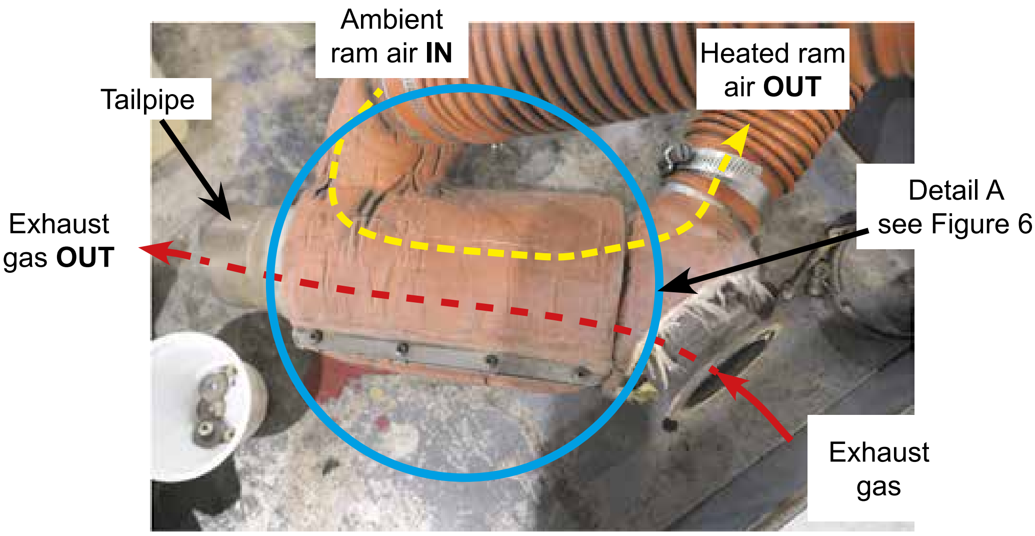

Figure 5

Right tailpipe and heater assembly removed
from a PA-46-310P aircraft

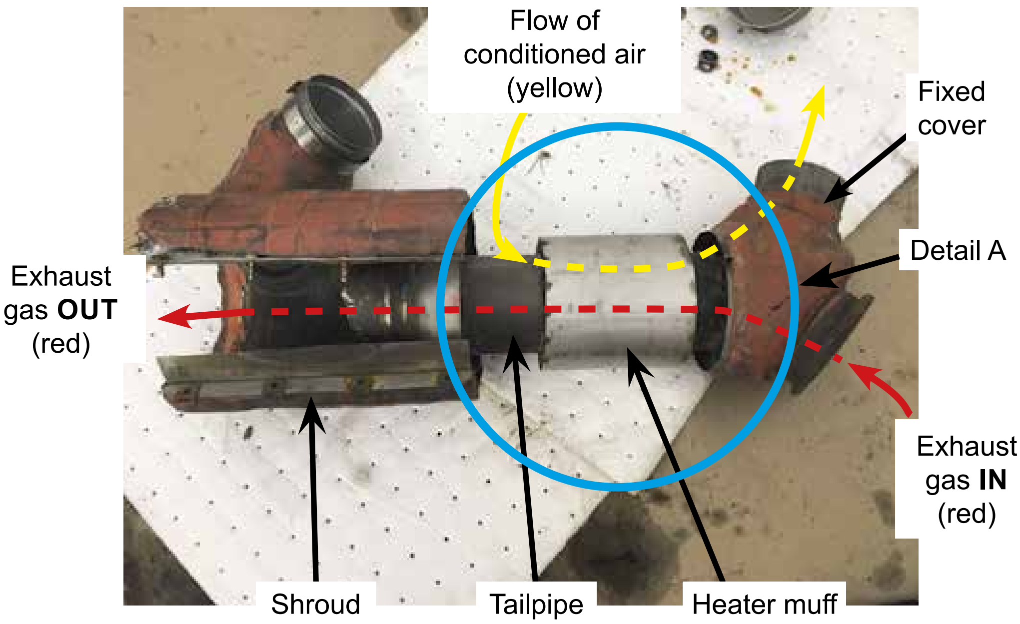

Figure 6

Ram air shroud removed from exhaust tailpipe / heater muff
from a PA-46-310P tailpipe

The engine instruments are located to the right of the pilot's instrument panel and consist of: a manifold air pressure and fuel gauge; rpm gauge; Turbine Inlet Temperature (TIT) gauge; and a single gauge that shows the oil pressure, oil temperature and cylinder head temperature. The minimum permitted oil pressure is 10 psi at idle and 30 psi at normal cruise power. The OIL PRESSURE annunciator forms part of the annunciator panel located above the engine gauges and illuminates when engine oil pressure drops below 20 ± 4 psi.

1.6.3.2 Engine history

The engine fitted to N264DB was built on 9 December 1998 and initially fitted to another PA-46-310P aircraft, registration VH-BGK. After a modification[11] in March 2003, the engine was fitted to N264DB on 28 May 2004 at 585.8 engine hours. Both turbochargers were replaced with overhauled[12] items during the Annual maintenance completed in December 2017. At the Annual maintenance carried out in November 2018, the engine had used 1,195.12 hours of its 1,400-hour overhaul life.

1.6.4 Previous failures of turbocharger turbines

While the investigation into the loss of N264DB was taking place, the NTSB was investigating two events on a different aircraft type with a similar exhaust system where the turbine on a turbocharger separated from the compressor and exited through the exhaust. The turbines left score marks on the inside of the exhaust but did not puncture the exhaust tailpipe. There was no oil residue in the exhaust tailpipe. These turbochargers, which had been overhauled at a different facility, were similar to the turbochargers fitted to N264DB.

As part of the NTSB investigation, a Teledyne Continental TSIO-550 engine was run with two turbochargers, one of which was missing its turbine. The tests showed that without the turbine fitted to the turbocharger the engine would continue to run at cruise power setting, but would lose all its usable oil (five quarts) in two minutes. Similar results would be expected from a failure of the turbocharger on the engine fitted to N264DB.

1.6.5 Minimum equipment list (MEL)

The aircraft manufacturer has not issued an MEL[13] for the PA-46-310P, nor was an MEL required for N264DB as it was only permitted to operate for non-commercial purposes in accordance with 14 CFR Part 91[14]. It is the

11 The engine logbook records that the engine was converted to 'Jet Prop Delux'.
12 Both overhauled turbochargers were supplied with an FAA Form 8130-3 Authorized Release Certificate.
13 A minimum equipment list (MEL) is required by the FAA when operating under 14 CFR Part 125 (Non-airline large aircraft operations) and 14 CFR Part 135 (commuter and on-demand operations) or when operating turbine powered aircraft.
14 14 CFR Part 91 – *General Operating and Flight Rules*.

responsibility of the aircraft commander to consider any faults or deficiencies before commencing a flight to ensure that it can be completed safely.

1.6.6 Limitations

Section 2 of the Pilot's Operating Handbook specifies operating limitations for the aircraft. Relevant limitations are set out below.

Airspeed limitations:

	KIAS	KCAS
V_{NE}[15]	203	200
V_{NO}[16]	173	170
V_A[17] (4,100 lb)	135	133
V_A (2,450 lb)	103	102
V_S[18] (1g clean)	69	

Manoeuvre limitations:

No aerobatic manoeuvres, including spins, are approved.

Flight load factors:

The approved maximum positive load factor is 3.8 g with the flaps up.

There is no approved maximum negative load factor. Inverted manoeuvres are not approved.

1.6.7 Safety equipment

N264DB was equipped with six seats: two forward-facing pilot seats at the front of the aircraft; two rearward-facing passenger seats in the middle; and two passenger seats at the rear of the cabin facing forwards. All passenger seats had adjustable backs (recline) with built-in headrests. The rearward-facing passenger seats were equipped with lap straps and all the forward-facing seats with three-point harnesses (car style). Entry to the aircraft was through a rear door on the left side of the cabin. An emergency exit was located on the right side of the cabin adjacent to the rearward facing passenger seat.

15 Never exceed speed. Do not exceed this speed in any operation.
16 Maximum structural cruising speed. Do not exceed this speed except in smooth air and then only with caution.
17 Design manoeuvring speed: the speed above which full or abrupt control movements are not permitted.
18 Stall speed with flaps up and landing gear retracted.

An Emergency Locator Transmitter (ELT) was installed in the rear fuselage and was accessible through a panel on the bottom right side of the fuselage. The ELT had a three-position switch: ON, OFF, ARM. When selected to ARM the ELT would automatically start to transmit when it detected an impact. The ELT was not designed to work under water.

The aircraft was equipped with a life jacket for each occupant and a six-man life raft, kept in the rear baggage compartment and accessible from the cabin. The passenger was not wearing a lifejacket when his body was recovered.

1.6.8 Ice protection system

The ice protection system was designed and tested for operation in the meteorological conditions specified in 14 CFR Part 25, Appendix C, for continuous-maximum and intermittent-maximum icing conditions. N264DB was not permitted to fly in severe icing conditions.

The ice protection system consisted of pneumatic wing and empennage[19] boots[20], a wing ice detection light, electrothermal propeller de-icing pads, an electrothermal windshield panel, a heated lift detector (stall warner) and a heated pitot head. It was demonstrated during certification that ice did not accumulate on the static pressure pads. However, if the static ports did become blocked by ice, an alternative static source located below the instrument panel could be selected.

The ice protection system on N264DB was found to be serviceable at the Annual maintenance completed on 30 November 2018, approximately 11 flight hours prior to the accident flight.

1.6.9 Autopilot

N264DB was equipped with a Bendix/King KFC150 3-axis autopilot system, incorporating a KC192 Flight Computer and a KAS297B altitude/vertical speed (VS) selector mounted on the forward instrument panel. The autopilot was engaged by pressing the AP ENG button on the flight computer, which engaged an attitude hold mode unless another mode button was also pressed. Selecting ALT engaged the altitude hold mode and the autopilot would maintain the selected altitude. Selecting HDG engaged the heading mode and the autopilot would turn the aircraft to the pilot's selected heading.

19 The empennage consists of the fin, rudder, stabiliser and elevators.
20 Flat array of flexible tubes bonded to the leading edge of wings, fins and other surfaces that are inflated to break up ice.

In HDG mode, this autopilot will turn an aircraft to a newly selected heading with a maximum bank angle of 22° +/- 2° which, at an airspeed of 150 kt, will result in a rate one turn ie 3.0º/sec. The maximum bank angle will be commanded whenever the heading bug is moved more than about 15° away from the current heading. If a smaller heading change is selected, a reduced bank angle is used resulting in a reduced turn rate.

The KAS297B Altitude / VS Selector is used to select a climb or descent rate and can be set to capture a selected altitude. The maximum climb or descent rate that can be selected is 3,000 fpm, with the flight director commanding a pitch attitude of between +15° and -10°.

A Control Wheel Steering (CWS) function is selected by depressing a switch on the pilot's control wheel. When the CWS switch is depressed and held, it disengages the autopilot's pitch, pitch trim, and roll servos and allows the pilot to control the airplane; it does not disengage the autopilot or the flight director. When the CWS switch is released, the autopilot and flight director are automatically synchronised to the aircraft's existing pitch attitude and altitude, if the ALT mode was previously selected. If the vertical speed mode was previously selected, the autopilot would control the vertical speed to the previously set value.

The autopilot automatically disengages if roll rates exceed 14°/sec or if the pitch rate exceeds 8°/sec.

1.6.10 Nosewheel steering

The nose gear is steerable through a 60° arc by use of the rudder pedals. Control rods connected to the rudder pedals pass through the pressurised bulkhead to the steering arms, which operate the nosewheel through a bungee assembly (Figure 7). The orifice in the pressurised bulkhead through which the control rods pass is sealed by a bellow assembly.

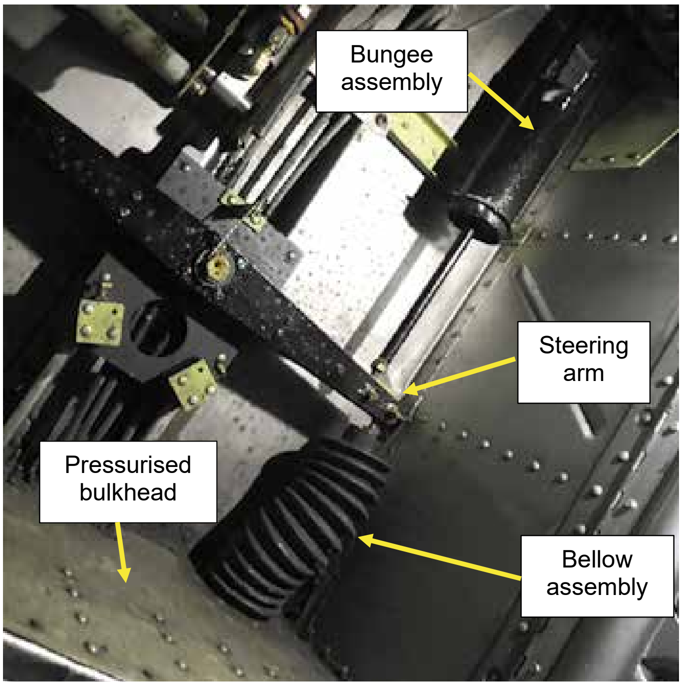

Figure 7

Nosewheel steering linkages on a PA-46-310P

1.6.11 Wheel brakes

Each main wheel is fitted with a single-disc brake assembly operated by toe brake pedals mounted on each pilot's rudder pedals. The brake hydraulic system, which has its own reservoir, is independent of the aircraft hydraulic system powering the undercarriage and flaps.

1.6.12 Audio warnings

Other than the momentary autopilot disengage warning, there are three audio warnings on the aircraft: stall warning, landing gear warning and a warning for operation of the ELT. The stall warner is the only warning to be provided by electrical power from the Main Busbar through the STALL WARN circuit breaker.

1.6.13 Cabin environmental system

1.6.13.1 General description

The PA-46-310P is equipped with an environmental system consisting of an engine bleed air and conditioning system, cabin air distribution system, pressurisation and control system, and a ventilating system.

1.6.13.2 Pressurised operation

The main components of the pressurisation control system are an outflow valve, a safety valve mounted on the aft pressure bulkhead, a cabin altitude controller and rate selector, and a triple gauge indicating cabin altitude, cabin rate of climb or descent, and differential pressure. The cabin pressurisation (CABIN PRESS) control and CABIN DUMP switches are mounted on the lower left side of the instrument panel with the cabin temperature (CABIN TEMP) control.

Pressurised air is taken from the compressor side of both engine turbochargers and routed to the pressurised side of the heat exchanger, where the temperature is controlled by the pilot operating the CABIN TEMP control (Figure 8).

When the CABIN PRESS control is pulled out, the firewall shutoff valve closes on the pressurised side of the heat exchanger, preventing pressurised bleed air entering the air distribution system. At the same time, the dump valve opens allowing the pressurised bleed air to escape into the engine compartment. When the CABIN PRESS control is pushed in, these valves change position allowing conditioned, pressurised bleed air to enter the cabin through the air distribution system. The CABIN PRESS control also moves the ram air selector valve to allow conditioned ram air to flow across the heat exchanger matrix and out of a vent on the right side of the aircraft.

The pressure in the cabin is controlled by the pilot, who modulates the amount of air escaping through the outflow valve by selecting the desired cabin altitude on the cabin altitude controller. The cabin altitude will remain at the selected altitude until the maximum cabin differential pressure of 5.5 psi is reached, at which time the cabin altitude will begin to climb until, at 25,000 ft, the cabin pressure will be approximately 8,000 ft. The cabin altitude rate-of-change (climb / descent) is controlled using the rate selector on the cabin altitude controller. The safety valve is independent of the pressurisation system and operates if the differential pressure exceeds 5.6 psi. The safety valve can also be selected fully open using the CABIN DUMP switch to rapidly depressurise the cabin or to allow unpressurised operation.

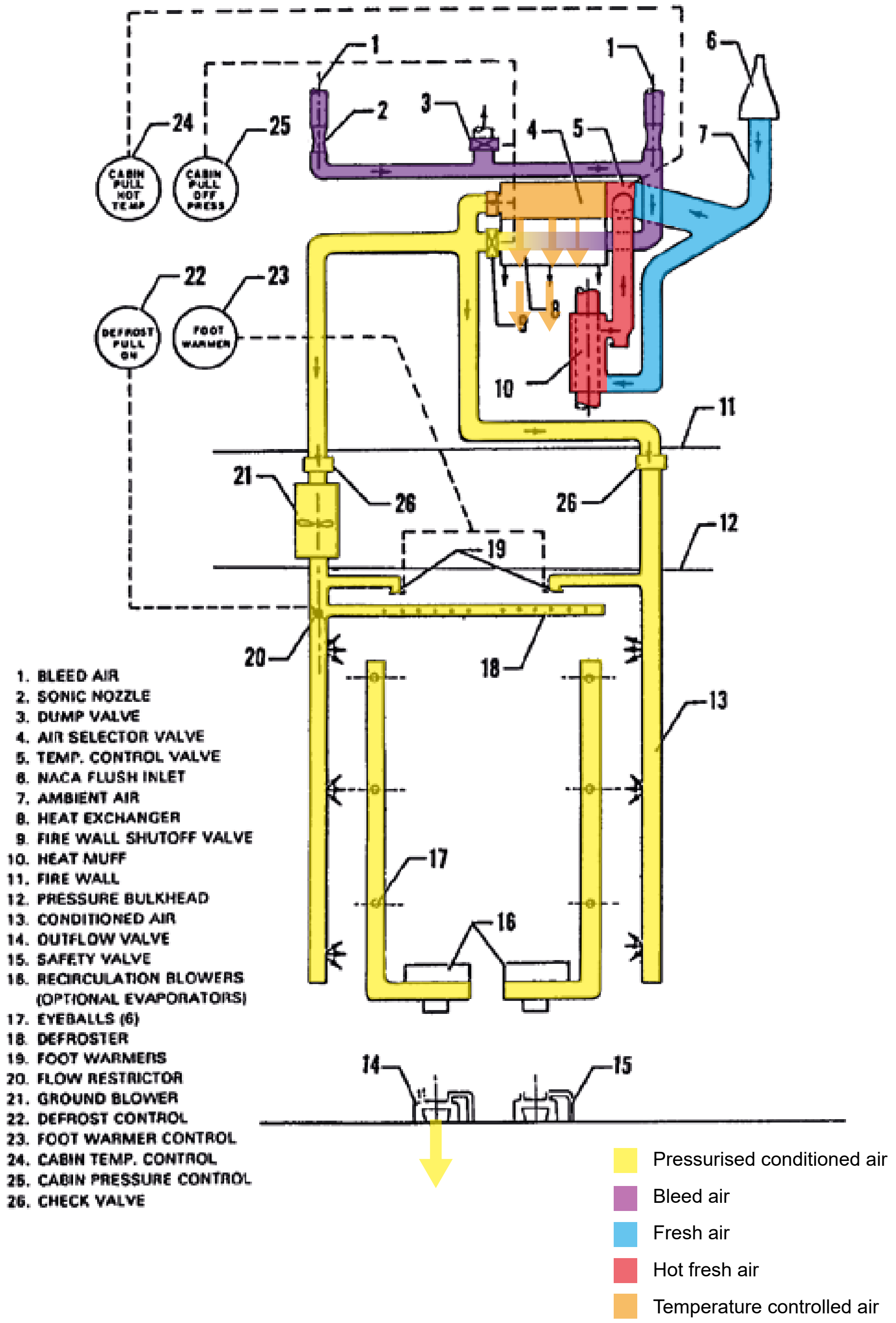

Figure 8

Cabin conditioning - pressurisation

1.6.13.3 Unpressurised operation

When the aircraft is unpressurised, fresh ram air enters the ventilation system through a NACA duct[21] located on the right side of the engine cowling (Figure 9).

21 NACA is the National Advisory Committee for Aeronautics, and a NACA duct is a low drag air inlet.

Some of this cold air is directed through a heater muff fitted around the engine's right exhaust tailpipe, which raises the temperature of the fresh air. This heated air is then re-mixed with the colder fresh air and directed through the cabin ventilation system. Air exits the cabin through the safety valve located on the aft pressure bulkhead.

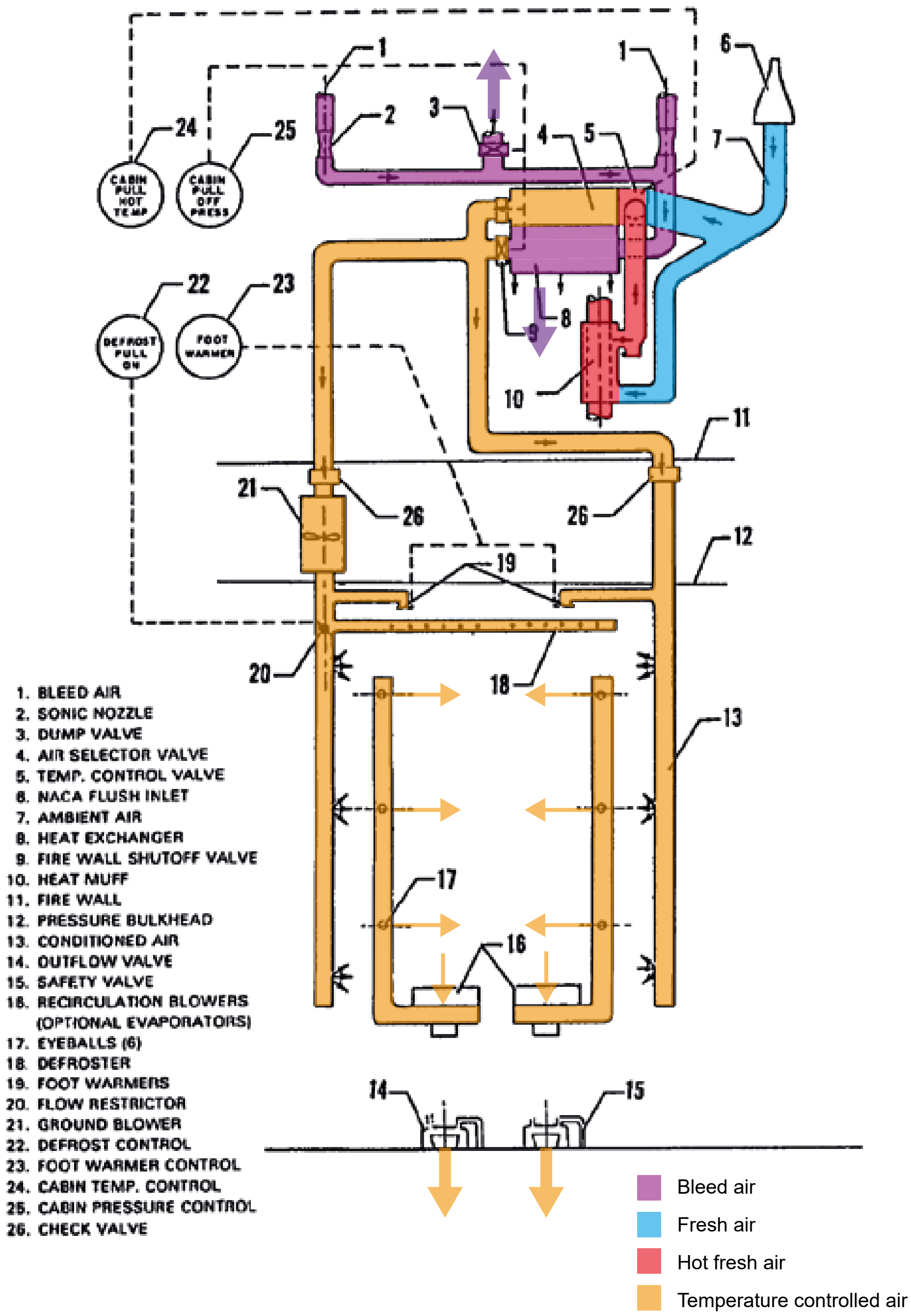

Figure 9

Cabin conditioning – unpressurised

For unpressurised flight, the CABIN PRESS control should be pulled to OFF and the CABIN DUMP switch selected ON, to open the safety valve, thereby providing maximum airflow through the cabin.

The unpressurised ventilation system is designed such that the pressure of the fresh ram air in the heater muff / shroud is higher than the ambient pressure of the exhaust gas. This design feature is intended to prevent fumes from entering the air distribution system via the heater muff should a crack occur in the exhaust tailpipe.

1.6.13.4 Cabin air distribution

The cabin air distribution system consists of left and right-side panel ducting, windshield defrosting, pilot foot warmers and ventilation blowers. The side panel ducts provide for overall air distribution throughout the length of the cabin near floor level. Two recirculation blowers, situated behind the rear passenger seats, supply airflow to the portion of the sidewall ducts containing the individual adjustable seat outlets (eyeballs). The pilot can select the recirculation blower to OFF, LOW or HIGH.

1.6.14 Maintenance and fault history

A description of the recent scheduled maintenance and fault history of N264DB is at Appendix A.

1.6.14.1 Registration and recent maintenance

N264DB was manufactured in 1984, and on 30 November 2018 the aircraft had flown 6,636 hrs and the engine had operated for 1,195 hrs since overhaul. The Certificate of Registration was issued on 11 September 2015 with an expiry date of 30 September 2021. The Airworthiness Certificate was dated 27 April 1984. Airworthiness Certificates[22] remain valid if aircraft maintenance is performed in accordance with 14 CFR Parts 21, 43 or 91, as applicable. The last significant maintenance of N264DB was an Annual / 100-hour maintenance completed on 30 November 2018; the Certificate of Release to Service was signed by the holder of an FAA Inspector Authorization (IA)[23].

1.6.14.2 Annual inspection and 100-hour maintenance

The last Annual inspection and 100-hour maintenance was completed on 30 November 2018 at 6,636.2 airframe hours, which was approximately 11 flying hours before the accident flight. The undercarriage circuit breaker

22 CFR Part 91.203 (b) states '*No person may operate a civil aircraft unless the airworthiness certificate …is displayed at the cabin or cockpit entrance so that it is legible to passengers or crew*'.
23 See sections 1.17.1.2 to 1.17.1.4 *Inspection and maintenance.*

was replaced during this maintenance activity. The Certificate of Release to Service included a statement that: '*the Altimeter and Transponder were due 24/07/17*'. FAA regulations only permit aircraft to fly in controlled airspace under IFR providing each altimeter and automatic pressure altitude reporting system has been tested and inspected within the previous 24 months. The FAA IA reported that the instruments had not been placarded to highlight this limitation because it was an operational and not an airworthiness requirement. For the same reason, this limitation was not annotated in the aircraft logbook or Release to Service. The FAA IA advised that a copy of the Release to Service was attached to the aircraft journey log.

The previous Annual inspection and 100-hour maintenance were completed by a different maintenance organisation on 15 December 2017, at 6,583.4 airframe hours. During this maintenance activity, both turbochargers were replaced, two cylinders were overhauled, and parts of the exhaust system were replaced. The right tailpipe / heater muff would have been removed during this activity. A considerable amount of other maintenance work was carried out, and the following statement was recorded on the Certificate of Release to Service:

> *'FAA FAR 91.411, Altimeter calibration insp NOT carried out. No IFR flight permitted.*
>
> *FAR 91.413, Transponder calibration insp NOT carried out, No flight in Class A, B or C airspace permitted.'*

1.6.14.3 Inspection of the engine exhaust system

The last Annual inspection was carried out in accordance with the 100-hour inspection schedule specified in the aircraft manufacturer's maintenance manual[24]. The exhaust tailpipes were removed from both turbochargers during the inspection in order to examine the turbines. The maintenance organisation informed the investigation that the heater muff shroud was removed, and a visual inspection was carried out using mirrors and a light source in accordance with the guidance in the engine manufacturer's Service Bulletin, SB10-1A[25]. The SB also contains guidance on how to pressure-test the exhaust system, but this was not done because the mechanic and inspector were satisfied that they could establish the condition of the exhaust and heater muff by the visual inspection alone.

The following inspections were annotated on the maintenance schedule as having been carried out to ensure the integrity of the engine exhaust, firewall and ventilation system.

24 Piper Aircraft PA-46-310P /350P Maintenance Manual.
25 Continental Motors Aircraft Engine Service Bulletin, Category 3, SB10-1A, Revision A. See paragraph 1.17.1.4.

'B. Engine Group

37. Inspect exhaust stacks for cracks, hot spots, and security. Inspect gaskets for leakage and condition (Replace gaskets as required).

38. Inspect exhaust pipe and heater exchanger. (refer[26] to 81-2-00, Turbocharger and Exhaust System Visual Inspection).

39. Inspect exhaust heat shield and cross-over tubes for cracks and conditions.

48. Inspect firewall for cracks, condition, and security.

49. Check condition of firewall sealing.

C. Turbocharger Group

1. Visually inspect system for oil leaks, exhaust system leaks and general condition. (See 81-20-00, Turbocharger and Exhaust System Visual Inspection)

11. Inspect induction and exhaust components for worn or damaged areas, loose clamps, cracks and leaks.

D. Cabin and Cockpit Group

23. Check condition of environmental system ducts.'

1.6.14.4 Recent fault history

It is good practice to use a technical log on aircraft which are flown by different pilots to record details of flights, airframe and engine hours, faults, and equipment which is not serviceable. However, this is not mandatory for private aircraft operated under the provisions of 14 CFR Part 91. Therefore, N264DB was not required to have a technical log and one was not used; instead the aircraft had a journey log which recorded the destinations and hours flown.

The person who managed the operation of N264DB informed the AAIB that pilots would verbally inform him of any faults on the aircraft and he would either arrange for them to be rectified or verbally inform the next pilot of any outstanding faults or limitations. He stated that he was not aware of any faults on the aircraft, other than the faults reported by the pilot when the aircraft was at Nantes. As far as he was aware, the anti-ice system and autopilot were serviceable and there was no limitation on the operation of the aircraft when it departed Retford Gamston Airport to collect the passenger from Cardiff for the outbound flight to Nantes.

26 Piper Aircraft PA-46-310P / 350P Maintenance Manual, Chapter 81-2-00. Turbines.

A description of significant faults discovered on the aircraft during the previous three years and the rectification carried out is at Appendix A. The aircraft documentation showed that on 12 July 2017 there was a fault with the flight director and autopilot, which often disengaged uncommanded. The fault was subsequently investigated by an avionic technician who recommended that the autopilot computer should be replaced with a later model. He also placarded the autopilot and flight director as 'INOP' (inoperative). The FAA IA who inspected the aircraft in 2018 recalled that there was a placard for 'no autopilot'. The investigation found no evidence that the computer had been replaced or the intermittent fault rectified.

1.6.14.5 Faults arising during the flight to Nantes

The investigation established that there were several faults on the aircraft which became apparent to the pilot during the flight to Nantes:

- After the flight, the pilot reported to Witness 'A' that during the cruise mid-way across the English Channel there had been a 'bang', which he also described as a 'boom'. At the same time as the bang, he sensed a low-level mist throughout the airframe, which he indicated he had occasionally experienced before. The pilot pushed the throttle, mixture and propeller control levers forward and checked the engine parameters which were all within normal operating limits. The pilot described the same event to an FAA IA in the UK as a 'muffled thud' that occurred on the approach to Nantes, making no mention of the mist. The following day, the pilot removed the engine cowlings, examined the engine and carried out a ground run. All the engine pressures and temperatures were within limits and the pilot reported to Witness 'A' that there was no problem with the engine.

- After landing and while taxiing, the pilot experienced a loss of pressure in the left brake pedal. By pumping the brake pedal he was able to gain sufficient pressure to operate the brakes. He mentioned the problem to ATC while taxiing along the runway and subsequently spoke to the FAA IA who advised him to seek engineering advice in Nantes. The pilot arranged for a mechanic at Nantes to check the brakes, who arrived at the aircraft on 21 January 2019 at approximately 1300 hrs. The mechanic said that they communicated in French and, while it was difficult to understand some of the words or sentences, he understood what the pilot was asking him to check. The mechanic reported that he identified only a slight difference of pressure between the brakes, with the right brake pedal slightly firmer than the left. No payment was made, or documentation completed. The pilot made no mention of any other problems with the aircraft, which the mechanic considered to be very clean on the inside and outside. While the mechanic held an EASA Part 66 licence, he did not hold any FAA licences.

- The pilot discussed with Witness ‘A’ an audio warning that sounded during the last 10 minutes of the flight and which the passenger could hear. The pilot stopped the warning when he was taxiing off the runway by pulling the circuit breaker for the stall warner. It was not determined if the circuit breaker was reset prior to the accident flight.

Following the engine ground run carried out at Nantes to investigate the bang on the outbound flight, the pilot noticed what he thought might be a small oil leak from the top of the oil accumulator, which he believed had been present for some time. The pilot took photographs, which he sent to the individual who managed the aircraft who then forwarded them to the FAA IA. From one of the photographs, the component was identified by the engine manufacturer as the air / oil separator assembly (Figure 10).

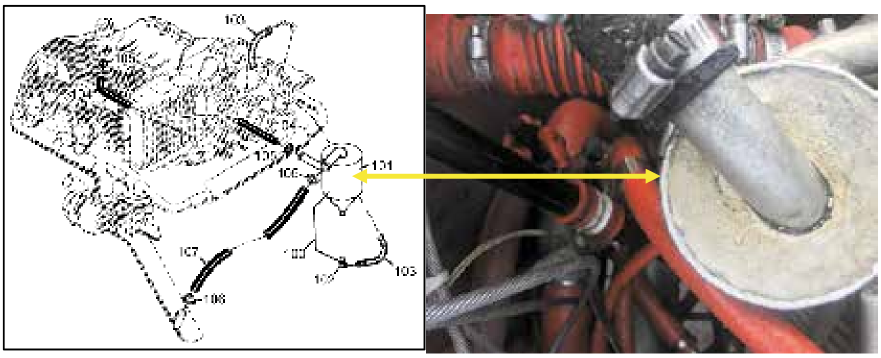

Figure 10

Photograph sent by pilot showing location of oil leak from the air / oil separator (item 101 in the left image)

The pilot brought some of these faults to the attention of the person who managed the aircraft, and the FAA IA who told the AAIB that he advised the pilot to have an engineer look at the aircraft. Apart from the mechanic at Nantes who tested the brakes by pressing the pedals, there was no evidence that an engineer examined any of the other faults before the aircraft departed on the accident flight.

1.6.15 Weight and balance

The AAIB could not determine how much fuel was in N264DB when it departed from Nantes. Using estimates of the weights of the pilot, passenger and luggage, it was calculated that the aircraft would have been under the maximum takeoff weight even if the fuel tanks had been completely full. It was also determined that the aircraft would have been within the centre of gravity limits at the time of the accident regardless of the fuel load at takeoff.

1.7 Meteorological information

Before departing from Nantes, the handling agent gave the pilot a weather pack which included reported and forecast weather for departure, destination and en-route airports, as well as weather charts for the route. It is not known if the pilot looked at these, but information from a witness who spoke to the pilot on the morning of the flight confirmed that he was aware of the weather situation. It is likely, based on his usual practice, that he used his tablet or mobile telephone to access weather information.

A weather forecast was issued by the Jersey Meteorological Department at 1502 hrs on 21 January 2019, valid for the period between 1600 hrs and 2200 hrs. This forecast showed a cold front moving in from the northwest, which was forecast to bring rain overnight. The forecast included the possibility of isolated showers for the whole period of validity. Observations at Guernsey Airport for 1950 hrs showed that the visibility was in excess of 10 km and the cloud was Few at 1,000 ft above airfield level (aal). At 2020 hrs, Guernsey was reporting light showers of rain and Few clouds at 1,000 ft aal.

The rainfall radar picture at 2015 hrs showed a band of showers, some heavy, passing through the area of flight as shown in Figure 11.

The crew of an aircraft flying in the area at the same time as N264DB reported that there were some cumulonimbus (CB) cells and that they had encountered some rain after descending below the bottom cloud layer. Data from the UK Met Office indicated that the freezing level around the Channel Islands was forecast to be between 3,000 ft and 4,000 ft amsl. The forecast indicated that any icing encountered would be light to moderate. Pilots in the area at the time reported encountering little or no ice at the altitudes that N264DB was flying.

There was a layer of complete cloud cover which had a base of between 11,000 ft and 13,000 ft amsl. Below that were a succession of layers of varying cover and thickness as the cold front approached. Forecasts from Jersey indicated that this cloud would have contained layers with bases between

4,000 ft and 6,000 ft, and between 1,500 ft and 3,000 ft amsl. Showers were forecast in the area from clouds with a base of between 1,000 ft and 1,500 ft. Other pilots who were flying in the area at the time suggested that there was little distinguishable horizon between the cloud layers.

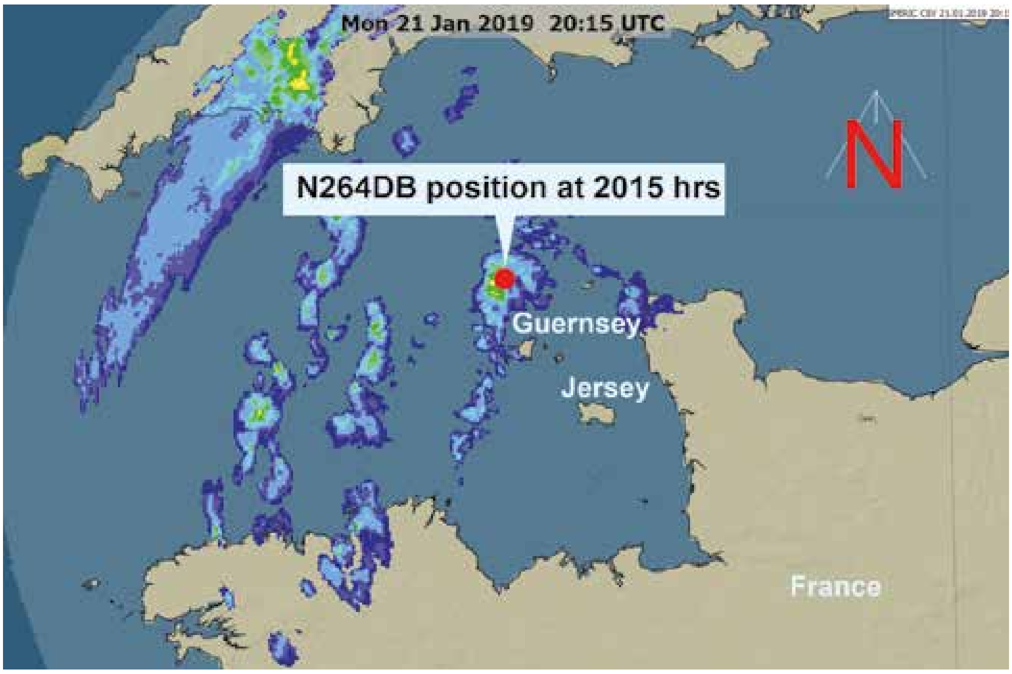

Figure 11

Rainfall radar and position of N264DB at 2015 hrs

Although there was a full moon, the sky was obscured by the high-level cloud and it would have been very dark below the main cloud base where N264DB was flying. Once the aircraft had passed to the north of Guernsey, there would have been few lights visible from the surface except for lights from surface vessels in the Channel. At the altitude at which the aircraft was flying, the horizon would have been visible between 80 and 90 nm away in perfect conditions, but there was rain and moisture in the atmosphere which would have obscured the horizon or reduced this distance significantly. The lights of the south coast of England were at least 43 nm away and it is likely that, given the conditions, they were not visible to the pilot.

1.8 Aids to navigation

A combined radio communications and GPS navigation unit[27] was fitted to the instrument panel of the aircraft. The unit could display aircraft position and the planned route overlaid on a moving map.

27 GNS530 manufactured by GARMIN.

1.9 Communications

1.9.1 Flight plan

The initial flight plan submitted for the flight from Nantes to Cardiff was for a departure time of 0900 hrs. This was refiled several times over 45 hours with the final flight plan being filed for a departure time of 1830 hrs. The investigation did not establish the reason for the delays to the departure time, or when the changes in time were conveyed to the pilot. Evidence from emails to the handling agents in both Cardiff and Nantes showed that the pilot was aware of the planned night-time return by the afternoon of 20 January 2019.

1.10 Aerodrome information

Nil.

1.11 Recorded information

1.11.1 Sources of recorded information

Recorded radar information (primary, and secondary Modes A and C[28]) was available from separate ground-based sites in Guernsey, Jersey and France. The radar data provided an almost complete record of the accident flight, starting as the aircraft took off and ending shortly before it struck the sea. The radar tracks derived from data from the different sites predominantly aligned[29], corroborating the relative accuracy of the independent data sources.

Recordings of radio communications between the pilot and ATC were available, including radio transmissions made during the approach and landing at Nantes on 19 January 2019, and all transmissions during the accident flight. CCTV at Nantes Airport also captured the period when the aircraft taxied to Runway 03 for takeoff.

The pilot used a flight planning and navigation software application installed on his portable tablet computer to create a route between Nantes and Cardiff and file the VFR flight plan. This information was uploaded to his cloud account. If used during flight, the tablet computer would have displayed aircraft position and planned route overlaid on a moving map, and recorded GPS-derived position information. The tablet computer was not seen in the wreckage.

The aircraft was not, and was not required to be, fitted with an accident-protected flight data recorder, image recorder or cockpit voice recorder.

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28 Mode A refers to the four-digit 'squawk' code set on the transponder, and Mode C refers to the aircraft's pressure altitude which is transmitted in 100 ft increments. Secondary radar typically provides greater accuracy than primary radar.

29 The radar positions captured from Guernsey, Jersey and France were typically within less than 100 m of each other.

1.11.2 Passenger's voice mail message

A copy of a voice message reported as being sent by the passenger of N264DB on the evening of 21 January 2019 was available and contained references to the flight.

Information from the provider of the passenger's voice mail application[30] showed that the last message from the passenger's account was received by the network at 1910:39 hrs UTC on 21 January 2019. This coincided with the period when N264DB taxied prior to takeoff. The voice mail recording contained background sounds that were consistent with normal operation of N264DB's engine on the ground.

1.11.3 The flight from takeoff until approximately 2005 hrs

The text below describes the flight from takeoff until approximately 2005 hrs and includes the track south of Guernsey shown in Figure 3. Altitude is derived from Mode C data (transmitted in 100 ft increments with a tolerance of ±50 ft), corrected for local atmospheric pressure (QNH)[31].

After departure from Nantes, N264DB climbed progressively to 5,500 ft amsl and its average ground speed was about 170 kt, equivalent to an estimated airspeed of about 160 KIAS based on a calculated wind from 250° at 25 kt. When the aircraft was about 20 nm south of Jersey, the pilot was transferred to the Jersey ATC frequency.

On initial contact with Jersey ATC, the aircraft was cleared to enter controlled airspace and maintain FL55[32], following which the pilot was asked to advise ATC if at any time he would not be able to "MAINTAIN VMC"; this was to enable ATC coordination with other aircraft in the area should it be necessary for N264DB to descend or climb. At 1958 hrs, the controller asked the pilot to check if the aircraft's altimeter pressure setting was correctly set to 1013 hPa, because the information on the radar indicated FL53. The pilot acknowledged and, shortly afterwards, the aircraft climbed to FL55; the aircraft was about 11 nm south-west of Jersey.

At 2002:10 hrs, N264DB was about 11 nm west of Jersey and 13 nm south of Guernsey when the pilot requested clearance to descend to "MAINTAIN VMC" (Figure 3). The aircraft was cleared to FL50, with the instruction to advise ATC if a further descent was required. Shortly afterwards, the aircraft began

30 WhatsApp: https://www.whatsapp.com/
31 Transmitted Mode C values are based on a standard pressure setting (see next footnote). This report has adjusted those values to reflect the local atmospheric pressure (QNH) so that they indicate altitude ie the vertical distance above mean sea level.
32 Flight Levels (FL) are referenced to the International Standard Atmosphere (ISA) pressure setting of 1013.25 hPa. FL55 is equivalent to 5,500 ft based on the standard pressure setting.

to descend whilst also making a right turn followed by a left turn (the calculated maximum bank angle during the right turn was about 22°, and during the left turn it exceeded 22°). This positioned the aircraft overhead Guernsey, displaced about 1.5 nm from, and parallel to the planned course. The controller then inquired if N264DB required a further descent, to which the pilot responded: "NEGATIVE, JUST AVOIDED A PATCH THERE BUT BACK ON HEADING FIVE THOUSAND FEET".

1.11.4 The flight after 2012 hrs

The following text describes the flight after 2012 hrs as shown in Figures 3 and 12. The altitudes were reported by the aircraft transponder with an accuracy of ± 50 ft.

At 2012 hrs, N264DB was about 11 nm north of Guernsey when the pilot requested a further descent to maintain VMC. The aircraft was cleared to descend at the pilot's discretion, and the pilot was given the Jersey QNH, which was 1017 hPa. The pilot acknowledged at 2012:32 hrs, and this was the last radio communication received from him.

N264DB started to descend gradually and turned onto a track of about 060°T. Approximately 30 seconds later the aircraft turned left to track about 305°T. During these turns the aircraft descended from 4,800 ft to 4,300 ft, climbed to 5,000 ft, and then descended again to 3,900 ft. The aircraft then proceeded to climb to 4,200 ft on a track that was nearly parallel with the planned course of 343°T. Its estimated airspeed was about 168 KIAS.

At 2015:30 hrs, N264DB started to make a gradual left turn, which was followed, at 2016:10 hrs, by a right turn of approximately 180°. During this turn, data from two independent radars (Guernsey and Jersey[33]) showed the aircraft descend from an altitude of 4,100 ft to an altitude of 1,600 ft in 28 seconds. As the aircraft descended, the aircraft's descent rate and airspeed increased, reaching calculated maximums of about 13,000 fpm and more than 220 KIAS respectively (V_{NE}[34] is 203 KIAS). Four seconds later, at 2016:34 hrs, the final secondary radar point was recorded indicating an altitude of 2,300 ft.

Following the final secondary radar point, two primary radar points were recorded by the Guernsey radar at 2016:38 hrs and 2016:50 hrs respectively. The wreckage was subsequently found to be within 100 m laterally of the final secondary radar point and the primary radar point recorded at 2016:38 hrs. The primary radar point timed at 2016:50 hrs was 1 nm from the wreckage position. It was not possible to definitively confirm the validity of the two final primary radar points, but the evidence indicated that the point at 2016:38 hrs was probably valid.

33 Data points were recorded once every four seconds by the radar located at Guernsey and once every five seconds for the radar located at Jersey (Les Platons).

34 See section 1.6.6, *Limitations*, for a definition of V_{NE}.

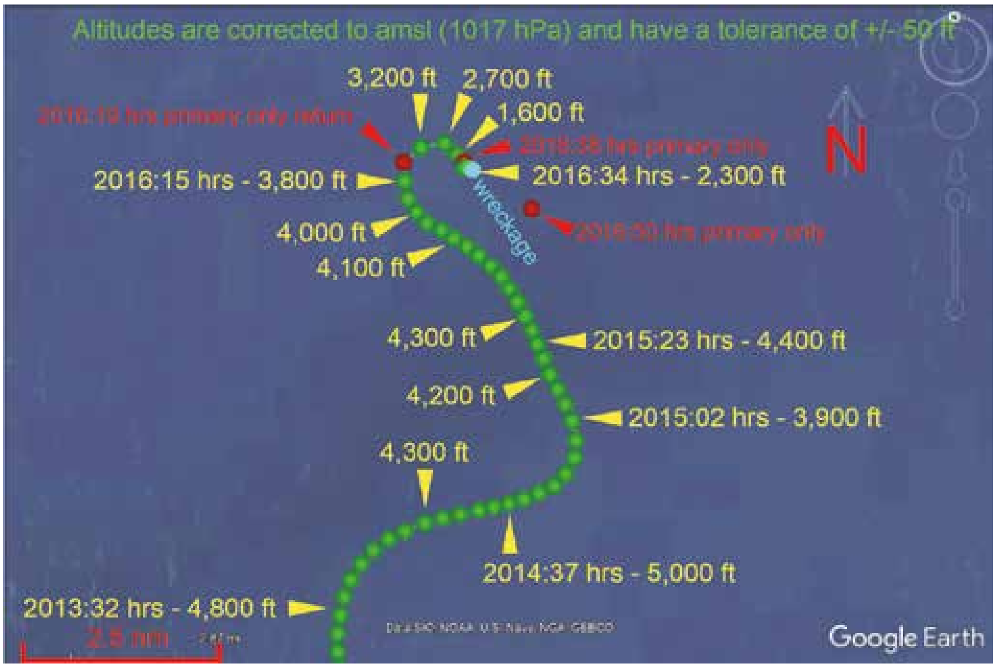

Figure 12

Radar track of final section of flight
(created from a combination of data from
Jersey (Les Platons) and Guernsey radars)

1.11.5 Mode C altitude validity

The digital altitude input to the transponder was provided by an altitude encoder installed behind the co-pilot's instrument panel. The encoder was connected to the same static pressure input used by the left and right altimeters installed in the instrument panel. Static pressure for the altimeters, vertical speed and airspeed indicators was sensed by two static source pads, one on each side of the rear fuselage forward of the elevator. The pads were connected to a single line leading to the instruments. The dual sources were designed to balance out differences in static pressure caused by slight 'side-slips' or 'skids'.

During the accident flight, when the aircraft was about 11 nm south-west of Jersey, the controller noticed that the aircraft altitude indicated FL53 instead of the requested FL55. Having queried with the pilot if the altimeter pressure setting was correctly set to 1013 hPa, the aircraft subsequently climbed to FL55. This was consistent with the pilot changing the altimeter pressure setting to 1013 hPa from 1020 hPa (the pressure setting previously provided by Rennes ATC prior to transferring to Jersey ATC). This also showed that the transponder output was consistent with the reading on the altimeter in the cockpit. The investigation found no fault with the transponder data.

Factual Information

1.12 Wreckage and impact information

1.12.1 General information on wreckage

The main wreckage of N264DB was located on 3 February 2019 approximately 22 nm north-north-west of Guernsey, at a depth of 68 m. This was within 100 m laterally of the final secondary radar position. A full description of the search for the wreckage is at Appendix B.

1.12.2 Initial survey

An initial survey of the wreckage, carried out using a camera on an underwater Remotely Operated Vehicle (ROV), revealed the presence of a body which was later identified as the passenger. The body was recovered to the ship on 6 February 2019. Despite a search of the wreckage and surrounding seabed, the pilot was not found.

A visual assessment of the wreckage was carried out using video footage taken from the ROV on 3 February 2019 and divers contracted by Blue Water Recoveries on 27 February 2019. There was a noticeable deterioration in the condition of the wreckage between the two dates.

The aircraft was extensively damaged, and the wreckage was in three parts held together by electrical and flying control cables. The engine had disconnected from the cockpit area, and the rear section of the fuselage had broken away from the forward section adjacent to the trailing edge of the wing. The horizontal stabiliser and fin, and outboard section of both wings were missing. The cockpit area and instrument panel were badly disrupted such that it would not have been possible with any confidence to determine the position of controls and switches prior to the crash. There was no visual evidence of fire.

1.12.3 Specific damage

The central fuselage had broken away from the nose section at Fuselage Station (F.S.)100 and from the tail section at F.S. 186.30 (shown in orange in Figure 13). The roof section of the central fuselage aft of the front seats was missing. There was significant compression damage along the top of the aircraft from the windscreens to the tail cone. There was no evidence of compression damage on the lower surface of the tail section. The fin and horizontal stabiliser assemblies had detached from the tail section at their attachment points (shaded blue).

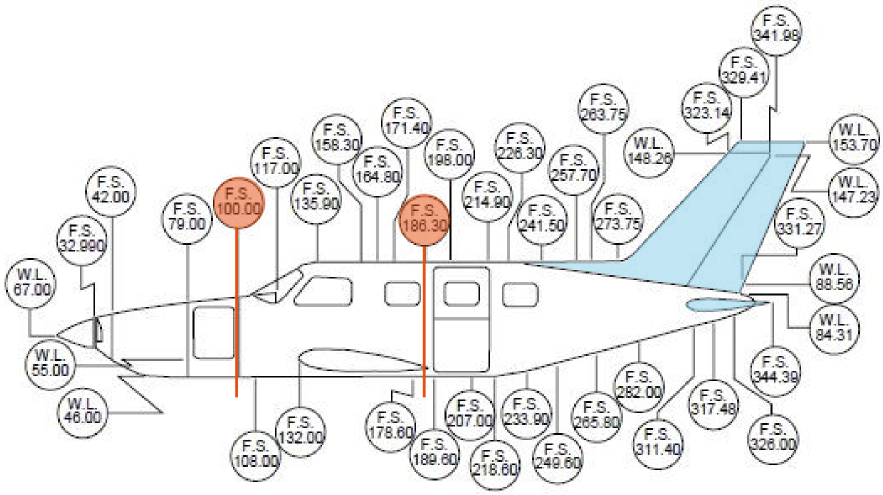

Figure 13

PA-46 fuselage

The left wing and flap had failed at Wing Station (W.S.) 107.56 (shown in orange in Figure 14) beneath the skin doubler plate where the inboard section of the wing joins the outer section (shaded blue) at the splice joint. The inboard section of the main wing spar appeared to be undamaged. The failure of the main spar splice joint and the adjacent structure was consistent with the wing failing due to a downward bending force. The top wing surface displayed evidence of a compressive force that had pushed the skins inwards with the edges having been torn away from the fasteners. The remainder of the wing structure and flaps were extensively damaged.

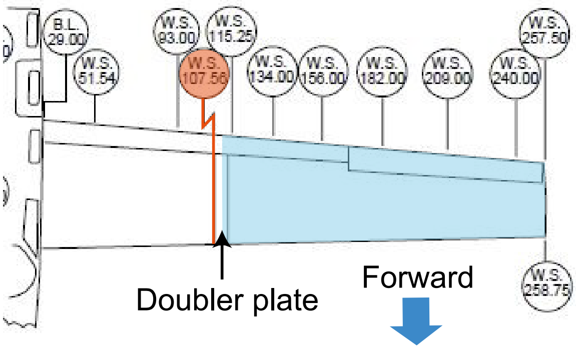

Figure 14

PA-46 left wing

The damage to the right wing, which also displayed evidence of compressive damage on the upper wing skins, was not as severe as the left wing. The right wing had also failed in the same area as the left wing, although it was not possible to determine from the video the direction in which the right wing failed. There was no evidence from the damage to either wing that the aircraft had been in a spin when it impacted the water.

Apart from a slight rearward bend in one of the blades, the propeller blades were undamaged. The engine cowlings had detached and the engine and nosewheel had rotated 90° relative to the front of the cockpit. Several components had detached from the engine. The right tailpipe / heater shroud was still attached to the right turbocharger and video footage of part of the right tailpipe showed no evidence of scoring on the inside. There was no evidence of burnt oil residue on the inside of the exhaust. The induction, heating and ventilation pipes, and the engine baffles had been disrupted. The ignition harness was still connected to the engine.

The cockpit and cabin area had been severely disrupted. The pilot's seat was intact, though the harness was missing. The harness for the right front seat was still in place and had been secured in a manner suggesting that this seat had not been occupied during the flight. Figures 15 to 20 show some of the damage described in this section. Further images of the wreckage are in Appendix B.

Figure 15

Damage to left wing

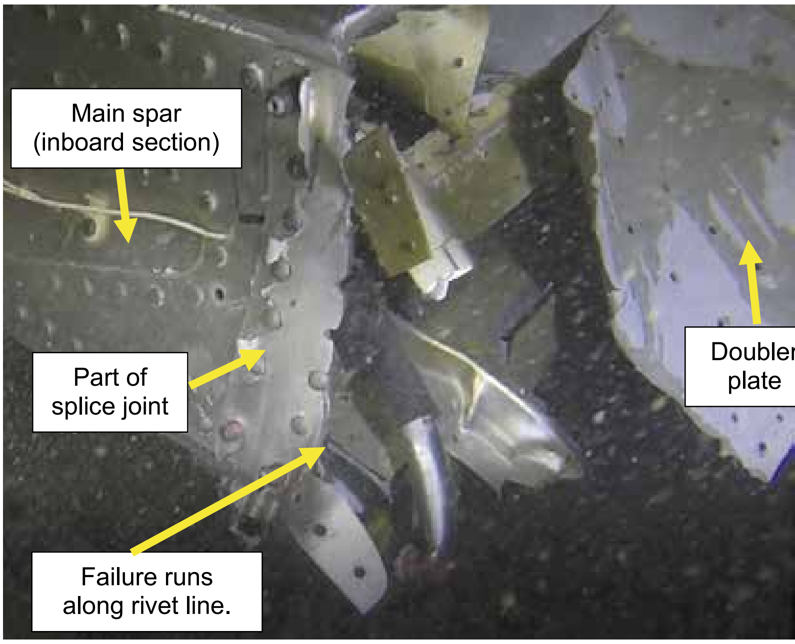

Figure 16

Failure of left-wing main spar at the splice joint
(Image taken from a video provided by Blue Water Recoveries)

Figure 17

Damage to cockpit roof

Figure 18

Break in central fuselage

Figure 19

Damage to roof of rear section of the fuselage
(This section of the fuselage has been rotated by the tidal flow)

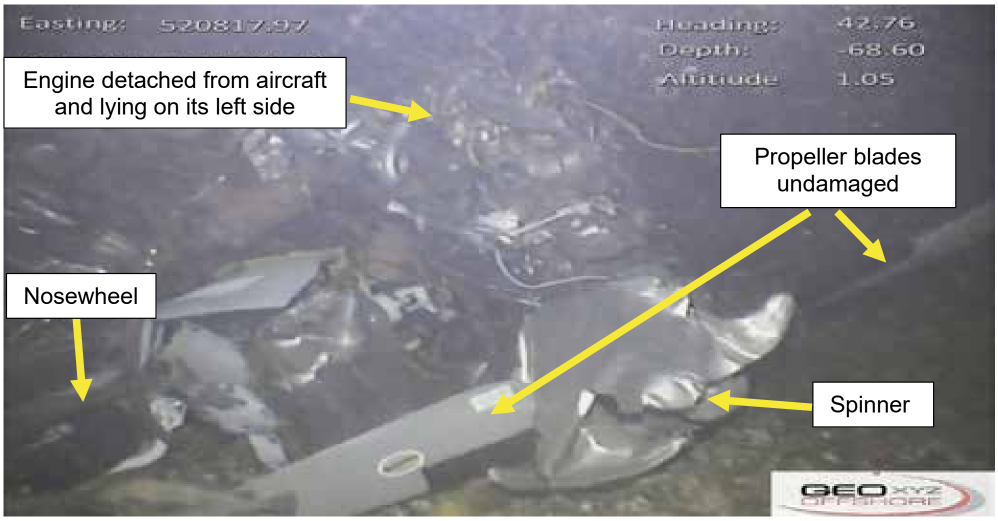

Figure 20

Propeller and engine

1.13 Medical and pathological information

1.13.1 Post-mortem examination result

Despite an extensive search of the wreckage and surrounding area the pilot's body was not found, and he remained missing at the time of publication of this report.

A post-mortem examination of the passenger recorded the cause of death as head and trunk injuries sustained in the accident impact. The pathologist reported that there was no evidence that the passenger had been exposed to a fire.

1.13.2 Toxicology

Post-mortem tests on the passenger showed a blood carboxyhaemoglobin (COHb) level of 58%[35], and the pathologist considered that he would almost certainly have been '*deeply unconscious'* at impact.

COHb is formed when carbon monoxide (CO) binds with haemoglobin in the blood. Haemoglobin is the oxygen-carrying molecule in red blood cells. CO is a colourless, odourless, tasteless gas, which is slightly lighter than air, and is a by-product of the incomplete combustion of carbon-containing materials. When inhaled, CO is easily absorbed into the bloodstream where it attaches itself to haemoglobin and has a direct effect on the performance of those

35 The pathologist confirmed that the COHb level could be relied upon despite the length of time the body had been under water.

parts of human physiology that rely on oxygen for proper functioning. CO inhalation can lead to damage to the brain, heart and nervous system, and this is known as CO poisoning.

The symptoms of CO poisoning worsen with an increasing level of COHb as detailed in Table 1.

COHb level	Symptom
Less than 10%	None
20 to 30 %	Drowsiness, headache, slight increase in respiratory rate
30 to 40%	Impaired judgement, shortness of breath, blurring of vision, bad headache, increasing drowsiness
40 to 50%	Confusion, marked shortness of breath, pounding headache, marked drowsiness, increasingly blurred vision
Over 50%	Unconsciousness and eventual death

Table 1

Symptoms of increasing levels of COHb
(Source, FAA Advisory brochure *'Carbon Monoxide: A Deadly Menace'*)

As the passenger and pilot were sitting in the same cabin, the pathologist considered it likely that the pilot would have been exposed to similar levels of CO as the passenger. Similar levels of COHb in the pilot's blood would have been expected to render him unable to fly an aircraft.

Video footage of the pilot and passenger passing through airport security at Nantes showed no behaviour which might be considered symptomatic of CO poisoning, such as a loss of coordination. Moreover, none of the witnesses at the airport commented adversely on the behaviour of either occupant of the aircraft prior to the flight.

1.14 Fire

The pilot made no mention of an airborne fire during his radio communication, there was no evidence of fire in any of the underwater videos, and the post-mortem report on the passenger identified no evidence of him having been exposed to a fire.

1.15 Survival aspects

The pilot and passenger did not speak a common language fluently and there was no written safety brief on the aircraft in any of the languages that the passenger spoke. Witnesses described the pilot and passenger communicating through hand gestures. Whilst the passenger may have regularly travelled on different types of aircraft, it would have been challenging for the pilot to have provided a comprehensive brief on the safety features on the aircraft and their use.

Whilst the aircraft was fitted with an ELT, the signal cannot be detected once the ELT is underwater. No signal was received from the aircraft.

The impact sequence was not considered survivable.

1.16 Tests and research

1.16.1 Simulation of the final manoeuvres

The final manoeuvre was analysed by the AAIB and NTSB. The NTSB used a 6-axis simulation[36] that calculated the aircraft's flightpath during the final manoeuvre, based on the recorded radar positions and altitudes, and output expected values for aircraft parameters such as bank angle, speed and normal load[37]. Normal loads during the final pull-up manoeuvre were also calculated by the AAIB using different analysis tools and the results were consistent with those of the NTSB simulation.

The NTSB simulation was run in two modes, referred to as 'altitude mode' and 'position mode'. In altitude mode, the final secondary radar altitude of 2,300 ft was treated as real, ie it was assumed that the aircraft descended to 1,600 ft and then climbed. In position mode the final altitude of 2,300 ft was ignored, ie it was assumed that the aircraft continued its descent towards the sea. Results from the two simulations, and radar data from the accident flight, are plotted in Figures 21 and 22.

During the right and left turns which started at 2013:32 hrs (Figure 12), it was calculated that the aircraft's roll attitude reached maximums of about 36° right and 56° left. The pitch attitude reached about 10° nose up as the aircraft initially climbed at up to 3,000 fpm, and about 15° nose down as it descended at up to 5,000 fpm. The calculated airspeed also varied between about 150 KIAS and 200 KIAS during these manoeuvres.

36 The software simulation used a generic 'unbreakable' aircraft model that followed the laws of aircraft motion, from which data such as attitude, speed and normal loads could be derived.
37 Normal load is the load (force) on the aircraft due to acceleration along the normal axis ie the axis which would extend vertically through the aircraft CG while sitting on level ground.

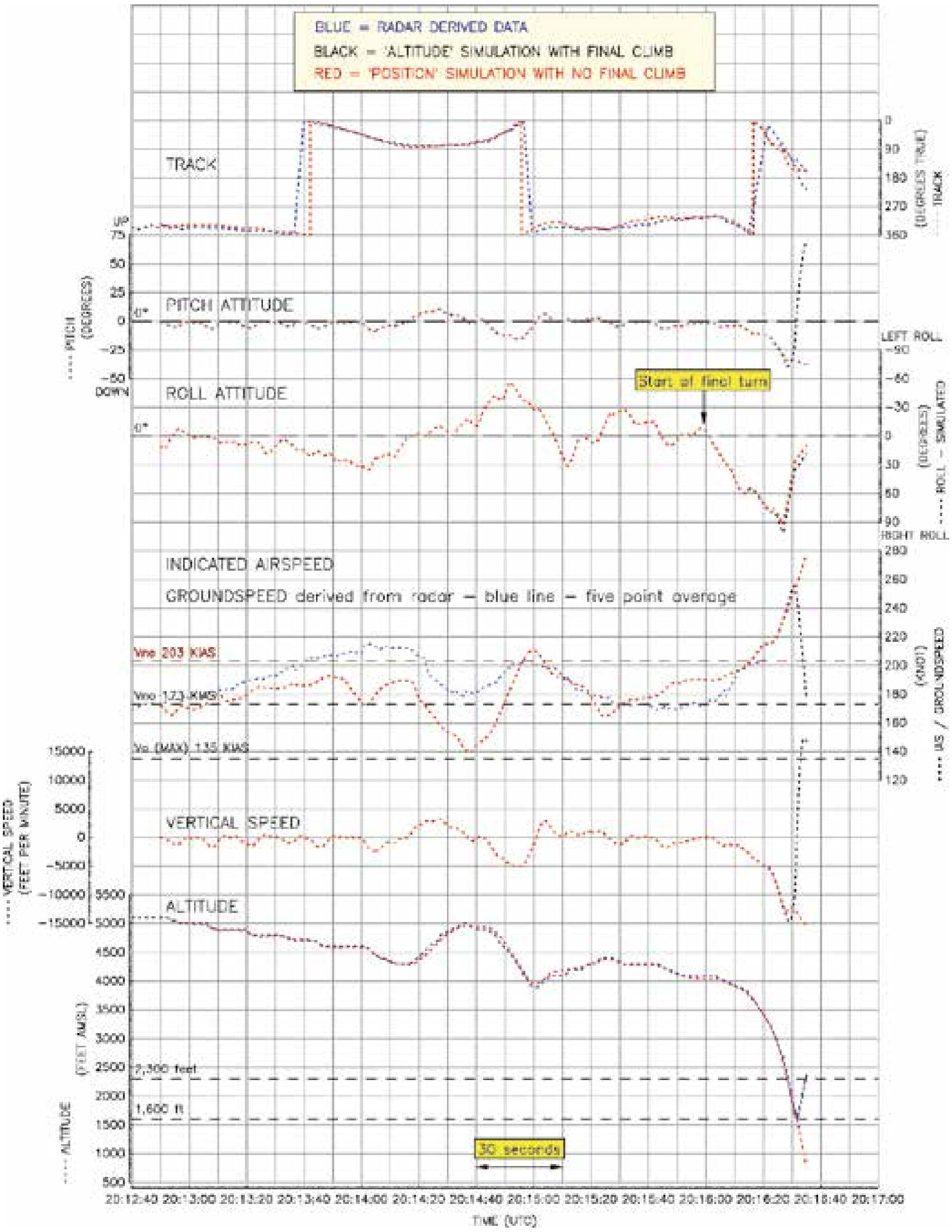

Figure 21

Radar and simulations data (commencing at 2012:40 hrs)

The aircraft commenced the final turn from an altitude of 4,100 ft and a calculated airspeed of approximately 180 KIAS. As it entered the turn, the roll attitude progressively increased at an average rate of about 5° per second and the airspeed increased at about 1.4 kt per second. When the right bank reached about 30°, both simulations indicated that there was a slight pause of a few seconds before the roll angle began to increase again. When the aircraft was at 3,700 ft, the roll attitude had reached about 60°, the pitch attitude was about 10° nose down, and the calculated airspeed was about 200 KIAS. There was another brief pause at this bank angle before it started to increase again. As the aircraft descended through 2,700 ft, the right bank had increased to about 90°, the pitch attitude was 30° nose down, and the estimated airspeed had increased to about 235 KIAS.

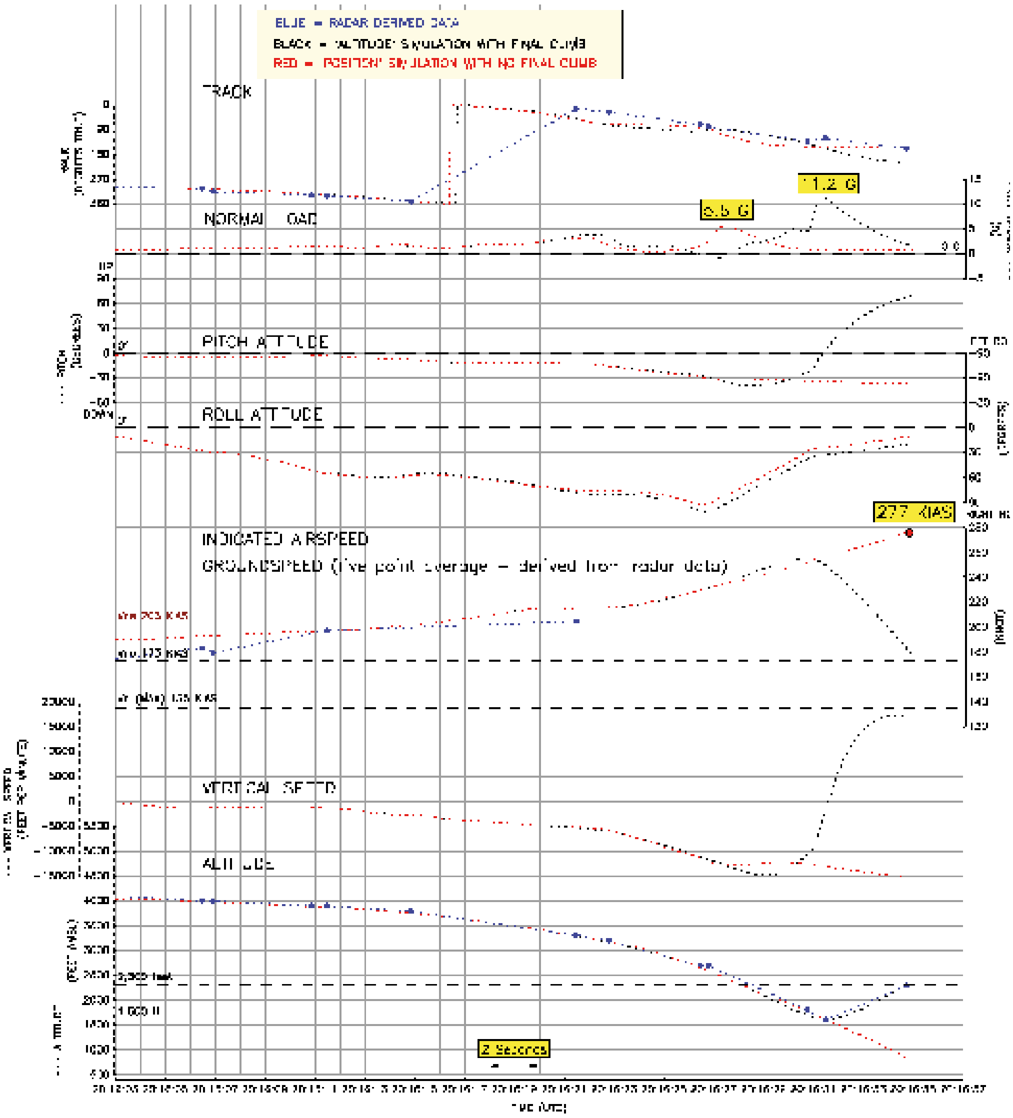

Figure 22

Estimated normal loads from simulations of final manoeuvre (commencing at 2016:03 hrs)

At an altitude of about 2,200 ft, the two simulations showed that the aircraft started to roll to the left, towards a wings level attitude. The results beyond this point diverged, due to the different flight paths required for the aircraft to have either climbed to 2,300 ft after reaching 1,600 ft, or to have continued to descend. The altitude mode simulation indicated that a maximum normal load of about 11 g would have been required during the pull-up manoeuvre, and the position mode simulation indicated that a maximum normal load of about 5.6 g would have been required at about the time the aircraft rolled left towards wings level. The position mode also indicated that, at the final secondary radar position, the aircraft's airspeed would have been about 280 KIAS and its altitude would have been approximately 800 ft.

1.16.2 NTSB investigations into in-flight structural failures of PA-46 aircraft

Between 31 May 1989 and 17 March 1991, five fatal accidents occurred in the USA, and a further two in Mexico and Japan, involving PA-46-310P and PA-46-350P aircraft that departed from controlled flight. In July 1990, following the fourth accident in the USA, the NTSB initiated a special investigation[38] into the causes of the accidents, which subsequently included all PA-46 accidents and occurrences that were reported during the period of the investigation.

The special investigation reviewed relevant design features, including structural integrity, flight control systems and operating limitations. The report recorded that the probable causes of the accidents that occurred in the USA involved failure to use pitot heat in freezing IMC, possible misuse of the integrated flight guidance and control systems, loss of control, and in-flight airframe failures due to loads and stresses that substantially exceeded design limits.

Of the five aircraft that had an in-flight breakup, four involved the PA-46-310P (Malibu) and one a PA-46-350P (Mirage). Three of the aircraft were found in an inverted attitude with the fuselage 'flattened'. The other two aircraft crashed into trees and the attitude of the aircraft at impact was not determined. In all the accidents, parts of the horizontal stabiliser and vertical stabiliser (fin) separated in flight and sections of both wings failed in flight, with the failures mostly occurring in the area of the wing spar splice joint. In three of the accidents, one wing failed as the result of an upward deflection and the other wing as a result of a downward deflection. An examination of the failed structure on the five aircraft found no evidence of fatigue fractures, pre-existing cracks, or corrosion. The fractures were all typical of overstress (overload).

In March 1990, the aircraft manufacturer performed supplemental static tests of a PA-46 stabiliser. The stabiliser was loaded until failure occurred and the test established that the load at which it failed exceeded the required ultimate loads for the '*gust-maximum torsion*' and '*maneuver-maximum bending*' conditions by 60% and 20% respectively. In May 1990, the aircraft manufacturer tested the elevator balance weights and found that failure loads exceeded design loads by 267%.

38 National Transportation Safety Board. *Special Investigation Report: Piper Aircraft Corporation PA-46 Malibu/Mirage Accidents/Incident May 31, 1989 to March 17, 1991*. PB92-917007. NTSB/SIR-92/03. Adopted July 21, 1992.

The manufacturer carried out a structural loads review of the wings and empennage. The review estimated that a minimum of 7.7 g would have been required to cause the wings to fail. Flight tests were also carried out on a PA-46-310P with instruments and strain gauges fitted to the empennage; during the tests, an acceleration of 4.2 g and an airspeed of 200 KCAS (203 KIAS) were recorded. All the manoeuvres performed exceeded design certification requirements, and the measured flight loads and stresses were all below tested limit loads and allowable stresses.

During the special investigation, NASA conducted an aeroelastic[39] analysis of the wing and horizontal stabiliser of the PA-46 to determine potential modes of structural failure. The results indicated that the aircraft was free of aeroelastic instabilities, such as flutter and static divergence, within its flight envelope.

The report also included the results of an FAA Special Certification Review[40] of the PA-46-310P that was initiated following seven in-flight structural break-ups. The review reported that:

> *'… the most likely accident scenario is one [involving an in-flight break-up] where the pilot loses control of the aircraft at altitude, the aircraft descends at increasing speed and breaks up as a result of dynamic pressure, or aerodynamic loads outside the certified flight envelope.'*

It concluded that:

> *'The structural substantiation[41] for the PA-46-310P and PA-46-350P was adequate for all conditions within the approved flight envelope.'*

1.17 Organisational and management information

1.17.1 Airworthiness requirements for operating a US-registered aircraft in the UK

1.17.1.1 Applicable regulation

N264DB was registered and operated in accordance with 14 CFR Part 91, *General Operating and Flight Rules*. Small, N-registered aircraft used for Air Charter operations are required to be operated in accordance with 14 CFR Part 135, *Operating requirements: Commuter and On Demand Operations and Rules Governing Persons On Board Such Aircraft.*

39 Aeroelastic analysis is concerned with the aerodynamic forces and the deformation of the structure.
40 FAA report dated December 1991: *Results of Special Certification Review of the Piper PA-310P (Malibu) and PA-46-350P (Mirage).*
41 Substantiation: Formal demonstration of compliance, eg with design fatigue-life requirements.

Part 91 allowed N264DB to be flown by private pilots holding an appropriate FAA or national licence, but the aircraft was not allowed to be used for commercial operations without the owner / operator first obtaining permission from the FAA and the CAA. Such permission had not been sought from or granted by these regulatory authorities for N264DB.

Part 91.403 states that the owner or operator of an aircraft is responsible for maintaining the aircraft in an airworthy condition.

1.17.1.2 Inspection and maintenance - general

Aircraft registered in the USA but resident in the UK and operated in accordance with 14 CFR Part 91 are maintained in accordance with Part 43. Part 91.409(a) states that an aircraft may not be operated unless within the preceding 12 calendar months it has had an Annual inspection and has been approved for Return to Service by a person authorised by Part 43.7. Part 43 provides the scope and detail of items to be included in the Annual and 100-hour inspections (Appendix D).

Inspections can only be undertaken by a person holding an FAA Inspector Authorization (IA), of which there were 18 in the UK at the time of the accident. Preventive maintenance and rectification can be carried out by individuals holding an FAA A&P[42] licence, and non-certified individuals can carry out maintenance and rectification provided they are supervised by an FAA A&P, who must be readily available.

Private aircraft, such as N264DB, can be maintained within the limits of the FAA regulations by the owner or a mechanic who must hold an FAA A&P licence in order to certify the maintenance before the aircraft is returned to service. The Airworthiness Certificate must be validated in the aircraft logbook by the holder of an FAA IA and renewed at the Annual inspection.

1.17.1.3 Inspection and maintenance – Aircraft Maintenance Manual

The PA-46-310P Maintenance Manual[43] provides the following definitions for the term 'inspection':

> *'A. Inspections - Must be performed only by persons authorized by the FAA or appropriate National Aviation Authority who are qualified on these aircraft, using acceptable methods, techniques and practices to determine physical condition and detect defects.*

42 A&P: Aircraft and Propulsion.
43 Piper Aircraft PA-46-310P / 350P Maintenance Manual, Chapter 5-20-00.

> *Routine Inspection – Consists of a visual examination or check of the aircraft and its components and systems without disassembly.*
>
> *Detailed Inspection – Consists of a thorough examination of the appliances the aircraft and the component and systems with such disassembly as is necessary to determine conditions.*
>
> *Special Inspection - Involves those components, systems or structure which by their application or intended use require an inspection peculiar to, more extensive in scope or at a time period other than that which is normally accomplished during the event inspection.'*

There were no specific requirements in the PA-46-310P aircraft maintenance schedule for the 50 and 100 hour inspection interval[44], for the tailpipe / heater muff to be removed and the exhaust system to be pressurised to check for leaks. It only called for the exhaust to be inspected. However, the following warning was in the introduction of the Maintenance Manual and at the start of the section on Scheduled Maintenance (Chapter 5-20-00).

> *'WARNING: FAILURE TO CONSULT APPLICABLE VENDOR PUBLICATION(S), WHEN SERVICING OR INSPECTING VENDOR EQUIPMENT INSTALLED IN PIPER AIRCRAFT, MAY RENDER THE AIRCRAFT UNAIRWORTHY. (SEE MAINTENANCE MANUAL – INTRODUCTION-SUPPLEMENTARY PUBLICATIONS.)'*

The introduction to the Maintenance Manual listed 26 components and stated: '*The following is a list of the vendor publications, used in conjunction with the servicing, overhaul and parts information on various components*.' Continental Motors was listed as the vendor for the engine fitted to the PA-46-310P.

1.17.1.4 Inspection and maintenance – Engine Manuals and Service Documents

The engine Standard Practice Maintenance Manual[45] and the Maintenance and Overhaul Manual[46] provide instruction and guidance for the continued airworthiness of the engine.

The engine manufacturer may issue Service Documents in one of six categories ranging from mandatory (Category 1) to informational (Category 6). Service Bulletin SB10-1A, which the maintenance organisation referred to during the

44 Piper Aircraft PA-46-310P / 350P Maintenance Manual, Chapter 5-20-00.
45 Continental Aircraft Engine, Maintenance Manual, Standard Practice for Spark Ignited Engines, Publication M-O.
46 Continental Aircraft Engine, TSIO-520-BE Overhaul Manual (Part No30574).

visual examination of the exhaust system[47], and which also contains guidance for pressure-testing the exhaust system, was a Category 3 Service Document. The content of SB10-1A had been incorporated into the Standard Practice Manual. The definition of a Category 3 Service Document is:

> ***'Category 3: Service Bulletin (SB)***
>
> *Information which the product manufacturer believes may improve the inherent Safety of an aircraft or aircraft component; this category includes the most recent updates to Instructions for Continued Airworthiness.'*

In comparison with Part 91, Part 135 maintenance requirements are stricter. Part 135.421 sets out the additional maintenance requirements, and for aircraft with nine seats or less, excluding the pilot's seat, operators must comply with the aircraft and engine manufacturer's recommended maintenance programmes or a programme approved by the FAA. Consequently, SB10-1A would be mandatory for aircraft operating in accordance with Part 135, and the pressure-test of the exhaust system would become a requirement.

1.17.1.5 Ownership and responsibility for airworthiness

Ownership of N264DB was transferred to a US Citizen Corporate Trust on 7 August 2015 to enable it to operate on the US register. The Trust, known by the FAA as the Trustee and by the CAA as the Owner Trust, is represented in the UK by a Limited company of the same name. In this type of arrangement, the Trustee is responsible for registering the aircraft and passing all applicable airworthiness directives to a Trustor (known by the CAA as the beneficial owner).

In the case of N264DB the Trustor was a UK company, and it was responsible for the operation of the aircraft and for ensuring it was maintained in accordance with applicable regulations. These responsibilities were recorded in a Trust Agreement and in an Aircraft Operating Agreement. Any further delegation of the Trustor's responsibilities was required to be made in writing and with the approval of the Trustee. The Trustor informed the investigation that it had delegated some of its responsibilities to a third party although there was no written contract between the parties.

Day-to-day management of the aircraft was carried out by the third party who also arranged scheduled maintenance and any necessary rectification. The Trustor paid any bills.

47 See paragraph 1.6.14.3, *Inspection of the engine exhaust system.*

1.17.1.6 Airworthiness oversight

Oversight of the maintenance of aircraft operating in the UK which are registered in another state is the responsibility of the state of registration. A bilateral agreement is in place between the UK and USA for the oversight of organisations performing complex maintenance under 14 CFR Part 145[48], and for operators of commuter and commercial aircraft under Parts 135[49] and 121[50]. This bilateral agreement does not place any obligation on the CAA for regulatory oversight of Part 91 maintenance organisations or individual N-registered aircraft operating in the UK. Nevertheless, the CAA may be asked to assist the FAA with safety checks.

1.17.1.7 Safety of foreign-registered aircraft operating in the UK

In 2016, the AAIB completed a Safety Study[51] into fatal general aviation (GA) accidents involving aircraft registered overseas, which revealed several common airworthiness issues. As a result of this study, the following recommendation was made to the CAA:

> '***Safety Recommendation 2015-040***
>
> *It is recommended that the United Kingdom Civil Aviation Authority take urgent action to ensure that foreign registered aircraft, permanently based and / or operated in the United Kingdom, comply with the requirements of the Air Navigation Order and their Certificate of Airworthiness.'*

The CAA subsequently undertook inspections of a sample of 24 non-UK registered aircraft with the results indicating that there was no significant difference in compliance between UK and foreign-registered GA aircraft resident in the UK.

In 2013, EASA undertook an internal analysis of N-registered aircraft in Europe over a five-year period. The study identified no significant difference in safety between aircraft registered in the USA and in the EU.

48 14 CFR Part 145 *Repair Stations*.
49 14 CFR Part 135 *Air Carrier and Operator Certificate (Rules for commuter and on-demand operations).*
50 14 CFR Part 121 *Air Carrier Certification (Rules for scheduled air carriers).*
51 AAIB Safety Study – 1/2016, *Airworthiness of Aircraft Registered Overseas and Resident in the UK*.

1.17.2 Chartering of aircraft

1.17.2.1 Organisation of the accident flight

The passenger on N264DB was transiting between his home in France and his new employer in Cardiff. The arrangements were made via a third party who asked the accident pilot whether he would be interested in flying the outbound and inbound flights. The passenger did not contribute to the cost of the flight, which was to be paid for by another party. The passenger was also not involved in booking the flight or in its arrangements beyond specifying the time at which he wished to depart from Nantes.

1.17.2.2 Assessment of risk

Passengers are not expected to know about or understand the regulatory aspects of aviation, such as airworthiness or personnel licensing or approvals. This knowledge is required of the commander and the operator, if there is one, who must ensure they comply with all relevant regulations. For this reason, a passenger is not likely to wholly understand the relative risk of a flight they are undertaking, which may vary according to the operating regime in which the aircraft is being used. For example, an operator with an AOC is subject to more stringent safety oversight by the regulator when compared to a pilot operating on a PPL with a hired aircraft. A pilot operating for an EASA AOC holder will be subject to six-monthly flying or simulator assessments, whilst an EASA PPL holder might only need to renew a flying rating every 24 months.

1.17.2.3 Unlicensed charters

Unlicensed charter flight operations, which can also be known as 'grey charters' are unregulated and may be uninsured. Evidence collected by The Air Charter Association indicated that such flights may have become more widespread within the UK and Europe. They are often associated with sporting events where there may be many small aircraft transporting passengers. Due to the unlicensed nature of such flights, it is difficult to gauge the level of activity accurately. Enforcement is challenging because it requires a large commitment of resources. It also requires the gathering of specific evidence against a pilot or broker which can be difficult to obtain. The Air Charter Association recommends specific steps[52] that passengers can take before hiring an aircraft for a charter to verify that the flight will be legitimate. These include asking if the aircraft is licensed and asking to see an AOC and the insurance documents for the aircraft.

52 https://www.theaircharterassociation.aero/baca-warns-of-grey-charters-in-the-eu/

1.17.2.4 UK regulatory approach to unlicensed charters

The CAA has looked at how unlicensed activity such as the accident flight can be stopped, taking a three-pronged approach.

The first part of the approach is to educate the travelling public who may unwittingly use one of these flights without realising that it is unlicensed and illegal. They unknowingly increase the level of risk they are taking and may be uninsured. Following this accident, the CAA developed a campaign to raise awareness of unlicensed charters. As part of the campaign it would:

- Engage with major sporting associations, business organisations and professional sports organisations to raise awareness of the issues and seek their public support.
- Distribute leaflets and posters aimed at passengers, explaining what to ask / look for when buying a non-airline flight.
- Provide AOC holders with material to show prospective passengers how they are more highly regulated and what that means.
- Increase the amount of information available on its website, with the search facility for AOC holders made more prominent.

A copy of the CAA Leaflet, *Legal to Fly,* is at Appendix C.

The second part of the CAA approach is to educate those who are unwittingly breaking the law because they do not understand or are unaware of the regulations surrounding air charters. The CAA can support the development of companies, individuals or owners who seek to become compliant with the regulations.

The final part of the CAA approach is to reduce the illegal activity by catching and / or prosecuting those involved. The CAA works together with other agencies such as the Border Force, Police and others to try and pinpoint where to target their resources. CAA inspectors regularly visit airfields as well as public events where aviation operations involving aircraft or helicopters take place. During such visits or inspections, the CAA monitors for any possible illegal activity. The CAA also carries out regular spot checks of flight plans. Reports from the public, especially from those within the legitimate aviation community can also provide useful intelligence to the investigators.

The CAA provides a form on its website where such reports can be filed, and they can be filed with 'Whistle-blower' protections[53].

Should illegal activity be suspected, the CAA has powers to detain an aircraft and, where appropriate, take enforcement action. Enforcement activities include educating the operator about the regulations, formal warnings, revocation of licences / approvals or certificates, and criminal prosecutions. The CAA, together with partner agencies, continues to develop capabilities which increase the chance that those engaged in unlicensed activities will be caught and sanctioned. The sensitive nature of this work means it remains largely hidden from public view.

The use of aircraft registered outside the UK does not prevent or deter the CAA from investigating, and it works closely with other worldwide regulators including the FAA. Whilst the CAA is not the regulator for these aircraft, it has sanctions available up to and including banning an aircraft from UK airspace.

1.17.3 Flight crew licensing requirements

To fly an aircraft registered in the USA a pilot must hold a suitable licence, and licensing is governed by 14 CFR Part 61, Certification: Pilots, Flight Instructors, and Ground Instructors. Part 61.3(a)(vii) states:

> *'When operating an aircraft within a foreign country, a pilot license issued by that country may be used.'*

Aviation in the EU is regulated by EASA, but pilot licences issued in accordance with EASA regulations are issued by Member State National Aviation Authorities (the CAA in the UK). A pilot may only hold one EASA licence, issued by a single Member State. The USA does not consider the EU to be a State and so a flight between two EASA Member States is a flight between two foreign countries within the meaning of Part 61.3(a)(vii). Such a flight would require the pilot to hold an EU licence issued in each Member State, which is not possible within the EU. Therefore, when an EASA licence issued in an EU Member State is used to fly an aircraft registered in the USA, the flight must remain within the borders of that Member State. The corollary is that, to fly an aircraft registered in the USA between two EU Member States, as was the case with the accident flight, a pilot must operate using an appropriate FAA licence.

Part 61 offers two routes to gain an FAA PPL and the first is laid out in Part 61.103. An FAA PPL would be gained this way by completing the FAA syllabus, examinations, flight training and flight test. Such a licence includes a night flying qualification because night flying is part of the FAA PPL syllabus.

53 The CAA is a "prescribed person" under the Public Interest Disclosure Act 1998 for the purpose of receiving "protected disclosures" (whistle-blowing) from the civil aviation industry.

The second way to gain an FAA PPL is through a certificate issued on the basis of a foreign pilot licence ('piggybacking'). The rules for this are contained in Part 61.75 which state that such a certificate:

> *'Is subject to the limitations and restrictions on the person's U.S. certificate and foreign pilot license when exercising the privileges of that U.S. pilot certificate in an aircraft of U.S. registry operating within or outside the United States.'*

It is possible for aircraft ratings and instrument ratings to be piggybacked onto an FAA licence from a foreign licence. For example, an FAA PPL issued on the basis of an EASA PPL could be used for night flying if the pilot held an EASA night rating (night flying is not included in the EASA PPL syllabus).

Both the EASA and CAA stated that, whilst operating in EASA-regulated airspace on a piggyback FAA licence, a licence holder must comply with EASA regulatory requirements with regards to the underlying EASA licence privileges. For example, a pilot cannot fly an aircraft without a valid class or type rating as required by EASA, or fly at night without completing the night flying training under Part-FCL.810. A pilot may not exercise the privileges of an FAA PPL issued on the basis of an EASA licence unless the underlying EASA licence is valid and contains the ratings and/or training required under EASA rules. In effect such a pilot when operating using a piggyback FAA PPL must comply with both the rules of Part 61 and those of EASA Part FCL, whichever are the most restricting.

1.17.3.1 CAA licensing records

Record-keeping related to personnel licences, certificates and ratings is a requirement under EU Regulation 2018/1119 (EASA Part ARA.GEN.220)[54], which has an associated Acceptable Means of Compliance (AMC). AMC1 ARA.GEN.220(a)(5), Record-keeping, advises that records should include, as a minimum:

- The application for, or change to a licence, certificate or rating.
- A copy of the licence or certificate including any changes.

Within the UK, pilot records are kept on an electronic database by the CAA. This database records ratings, renewals, medical details, and any applications pilots make to the CAA for alterations to their licence. The accident pilot's licence and logbook were not recovered from the wreckage, although the investigation saw a scanned copy of the pilot's licence from February 2018,

54 Part ARA, subpart GEN (General Information).220 and its associated Acceptable Means of Compliance at AMC1 ARA.GEN.220 (a)(5).

which had been sent to a third party by the pilot. This copy showed that the CAA records were incomplete because various revalidations had not been recorded on the database. Examination of the database also revealed ratings which had been entered on the pilot's record which he did not hold.

The issuing of ratings and the processing of renewals requires examiners and candidates to complete paperwork as detailed by the CAA. This paperwork is then submitted to the CAA to be processed so that the details can be entered into the database. The renewals are also entered directly onto the licence by the examiner, and the licence is the authoritative document. It was not determined whether the paperwork for the accident pilot's renewals was not submitted to the CAA or if it was not processed.

It is AAIB experience that CAA licensing records provided to AAIB investigations often appear to be incomplete.

1.18 Additional information

1.18.1 Carbon monoxide

1.18.1.1 CO detector fitted to N264DB

There was no record in the aircraft documentation of any type of CO detector having been fitted to N264DB. The individual who managed the aircraft believed that a strip detector was fitted to the right side of the instrument panel in front of the right seat although he had not fitted it. The maintenance organisations which undertook the Annual maintenance in November 2018, December 2017 and October 2016 had no record of a strip (spot) detector having been fitted to the aircraft.

CO strip (spot) detectors are normally mounted on a card, which is then stuck to a surface, and consist of a beige background which turns black in the presence of CO. The life of these type of detectors can be between 3 and 18 months from when they are removed from their original packaging.

1.18.1.2 Source of CO in the cabin of light aircraft

Piston engine aircraft produce high concentrations of CO that can potentially enter the cabin during flight as a result of cracks, holes or poorly fitted components in the exhaust system or intake ducting, or poor sealing of the firewall and critical areas of the fuselage / cabin.

Both 14 CFR Part 23.831 and European Certification Specification (CS) 23.831 (a) require manufacturers to show that the concentration of CO in the cabin will not exceed 1 part per 20,000 parts of air. To demonstrate compliance, the manufacturer usually installs a CO detector during the flight test programme, but there is no certification requirement for production aircraft to be equipped with a CO detector.

1.18.1.3 FAA report on detection and prevention of CO exposure

In October 2009, the FAA issued a report[55] on the detection and prevention of CO exposure in GA aircraft. The report looked at the design of exhaust systems and the protocols to alert users to the presence of excessive CO in the cabin and undertook an evaluation of inspection methods and maintenance practices.

A total of 71,712 accidents between 1962 and 2007 were reviewed from the NTSB accident / incident database and categorised as: clearly related to CO exposure; potentially related to CO exposure; or not related to CO exposure. Of the 71,712 accidents, 62 cases were clearly related to CO exposure. The 'potentially related' category included accidents where the probable cause involved engine failure, engine power loss, defective valves etc. However, without further analysis it was not possible to determine if CO poisoning was a factor. A search of the database using keywords related to the exhaust system identified approximately 400 cases which were related to the 'muffler'[56] (clearly and potentially related). The report also recorded that '*when the muffler was implicated as the cause of a CO related accident, the vast majority had muffler usage greater than 1,000 flying hours*'.

The report noted that piston engine exhaust gas typically contains 5% to 7% CO and extreme exposure can result in death in one to three minutes. Aircraft exhaust systems operate in a harsh environment and contain components and connections which can deteriorate and fail, allowing CO to enter the cabin. Some of the environmental factors that can cause a deterioration of an exhaust system include:

- Engine vibration, which may eventually cause metal fatigue.
- Thermal cycling during engine operations.
- High temperature and the corrosive effect of engine exhaust gasses.

The report highlighted that in the year 2000 the average age of the USA's 150,000 single-engine aircraft was over 30 years and that while the CO hazard is not limited to aging aircraft alone, the risk of exhaust system failure naturally increases with older aircraft. The report also noted that half of the exhaust system failures occurred within the first 400 hours of use.

55 U.S Department of Transportation, Federal Aviation Administration, DOT/FAA/AR-09/49, *Detection and Prevention of Carbon monoxide Exposure in General Aviation Aircraft*, October 2009.

56 A muffler is described by the engine manufacturer as a 'heater muff'.

The report included a finding by the NTSB that CO exposure can occur soon after an aircraft has completed its Annual or 100-hour inspection. Part of the reason for this might be that a crack is difficult to see in a simple visual inspection. The densely-packed engine compartment makes it difficult to perform a thorough inspection unless some parts are disassembled and removed. Even if the exhaust system is intact and without leaks during an inspection, it is possible for a crack or failure to occur soon after inspection. Service Difficulty Reports cited in the report highlighted exhaust system failures found after disassembly and pressure testing, even though the exhaust system had passed its Annual inspection a short time earlier.

The report found that:

- CO exposure is a serious hazard that can occur suddenly at any time.
- There is a high likelihood of a hazard from CO whenever there is an exhaust system failure.
- The best location for a CO detector is on the instrument panel.

1.18.1.4 Accidents and occurrences in the UK involving CO

Records of accidents and other occurrences in the UK since 2000 were reviewed to identify whether CO might have been a causal factor. The review identified two aircraft accidents[57], each with two fatalities, and fifteen other events recorded on the CAA occurrence reporting system. On 11 of those occasions, a CO monitor alerted the crew to the presence of CO; one crew was reported to be nearly unconscious when the aircraft landed; and the occupants on another four flights experienced nausea and light-headedness. There were seven other reported occurrences of exhaust fumes in the cockpit where the aircraft was not fitted with a monitor.

1.18.1.5 Recent significant events involving CO in cabins

29 August 2018 (N6500W)

On 29 August 2018 a Cessna P210N crashed just short of the runway in Prescott, Arizona, fatally injuring the pilot. The aircraft, which was destroyed by fire, is subject to an NTSB investigation[58].

The single engine piston aircraft was operating under the provision of 14 CFR Part 91. The pilot had intended to acquire his night

57 G-BGEW; accident occurred on 20 September 2009. AAIB reference EW/C2009/09/20. G-ARIE; accident occurred on 12 May 2001. AAIB reference EW/C2001/05/03.
58 National Transportation Safety Board Aviation Accident Investigation, N6500W, 29 August 2018.

rating currency by performing three practice touch-and-go takeoffs but crashed on his first approach.

The investigation established that there was a crack approximately 1.81 inches long with a maximum gap of approximately 0.20 inches wide along the exhaust manifold flange. The pilot had a COHb level of 35% which was not thought to have occurred as a result of the fire. The total engine running time for the flight was 18 minutes.

9 November 2018 (N91770)

On 9 November 2018, a Piper PA-28-236 collided with terrain about two miles south of Guthrie County Regional Airport, Iowa, USA. The four occupants onboard sustained fatal injuries. The accident is being investigated by the NTSB[59].

Examination of the wreckage revealed a crack, 2 inches long, in the engine's aft exhaust 'muffler' (heater muff). A toxicology report revealed that the COHb level of the occupants varied between 20% and 58%. The aircraft was being operated in accordance with the provisions of 14 CFR Part 91.

1.18.1.6 Safety Recommendations made by the NTSB

On 23 June 2004, the NTSB made a Safety Recommendation (A-04-028) to the FAA as a result of a fatal accident involving a Beech BE-23 aircraft where the pilot was probably incapacitated due to CO poisoning caused by a fractured 'muffler'. The NTSB investigation revealed that oxidation (corrosion) had penetrated the wall of the '*muffler shroud*' and extended around 20% of the 'muffler's' circumference. The oxidized areas of the fracture appeared black, which was consistent with a pre-existing fracture that was exposed to the environment for an extended period. The 'muffler' had been fitted to the engine for 27 years and 1,218 flight hours, and the accident occurred six flying hours after the aircraft's Annual inspection, which had been completed approximately three months earlier. The Safety Recommendation stated:

> ***'Safety Recommendation A-04-028.*** *'TO THE FEDERAL AVIATION ADMINISTRATION: Require the installation of carbon monoxide (CO) detectors meeting the standards developed as a result of Safety Recommendation A-04-27 in all single-engine reciprocating-powered airplanes with forward-mounted engines and enclosed cockpits that are already equipped with any airplane system needed for the operation of such a CO detector.'*

59 National Transportation Safety Board Aviation Accident Investigation, Number WPR19FA022, N91770, 9 November 2018.

The FAA response to the NTSB Safety Recommendation and the NTSB's assessment of their response are recorded respectively on the NTSB website as follows:

> *'As the proper inspection and maintenance of mufflers and exhaust system components is the primary method of preventing CO contamination, installing a CO detector is not necessary to correct an unsafe condition as defined by 14 CFR Part 39. Accordingly, the FAA does not plan to require the installation of such devices in all single-engine reciprocating-powered airplanes with forward-mounted engine and enclosed cockpits, as recommended.'*

> *'Although SAIB CE-10-19 R1 recommends that owners and operators of these aircraft review the FAA's technical report and also use a CO detector while operating their aircraft, the NTSB does not believe that issuance of the SAIB alone is satisfactory. Accordingly, because the FAA indicated that its actions in response to this recommendation are complete, Safety Recommendation A-04-28 is classified CLOSED—UNACCEPTABLE ACTION.*

1.18.1.7 Safety Recommendation made by the BEA (France)

In 2002, the BEA made Safety Recommendation FRAN-2003-002 (BEA) to the Direction Générale de l'Aviation Civile (DGAC), the French National Aviation Authority:

> **'*Safety Recommendation FRAN-2002-002 (BEA).*** *The BEA recommends that the DGAC require the presence of a carbon monoxide detector on general aviation aircraft.'*

The recommendation was addressed through EASA Rule Making Tasks (RMT) 0329 and 0330 which considered the proposal to fit CO detectors on board all piston engine aircraft. Work on these RMTs was suspended in 2013. Instead, it was proposed to ensure that there was an appropriate specification in CS 23[60]. With regard to this Safety Recommendation, EASA reported in their Annual Safety Review 2014:

> *'Although the safety risk from carbon monoxide (CO) ingress into the cabin of general aviation aircraft exists, the number of accidents where CO poisoning is determined as the root cause remains low compared to other root causes categories. CO detectors are also available on the market and as such many*

60 CS 23, *Certification Specifications for Normal-Category Aeroplanes*.

operators already make use of them, even though there is no rule requiring the installation of CO detectors.

The Agency considers that this issue may be treated by other means than by the creation of a new rule, and rulemaking task RMT.0329/.0330 has been cancelled. For instance, in June 2010, the Agency published Safety Information Bulletin (SIB) 2010-19 highlighting the importance and need to properly inspect and maintain the exhaust mufflers of piston engine powered Aeroplanes and Helicopters in accordance with the specifications for Inspection and Checks of the Appendix to the SIB.

Finally, in the frame of rulemaking task RMT.0498 on the re-organisation of the Certification Specifications for small aeroplanes (CS-23 and FAR Part-23), the Agency proposed to include a provision recommending the installation of CO detectors whenever the design of the aircraft presents a risk of contamination of the cabin air; such provision would be found in the ASTM standard which will be used in the future Book 2.'

1.18.1.8 Safety Recommendations made by the AAIB on CO monitoring

Following a fatal accident on 12 May 2001, the AAIB made the following Safety Recommendation to the CAA:

> ***'Safety Recommendation 2002-23***
>
> *The Civil Aviation Authority should develop an appropriate recognised performance specification against which carbon monoxide detectors can be assessed and approved, with the eventual aim of mandating their use on all piston engine aircraft.'*

The CAA partially accepted this recommendation and undertook a feasibility study to determine whether an appropriate airworthiness specification could be developed that would form the basis for a practicable and cost-effective CO detector for aviation use. The study proposed a revision[61] to updated ETSO[62] 2C48a which addressed the use of CO detectors. The study was circulated within the CAA Safety Regulation Group and provided to the EASA.

61 Revised ETSO for Carbon Monoxide Detectors, March 2005, Document 0529/R/000287/KK.
62 European Technical Standard Order (ETSO) is one process to have parts approved for use on aircraft.

The following Safety Recommendation was also made:

> ***'Safety Recommendation 2002-30***
>
> *In the absence of it being mandatory for all piston engine aircraft to carry a carbon monoxide detector, the Civil Aviation Authority should vigorously promote that all such aircraft should have a current carbon monoxide detector fitted to facilitate an early warning of the presence of the gas.'*

The CAA accepted this recommendation.

1.18.1.9 Response from the CAA to a Coroner on exposure to CO

Following an accident[63] in November 2017 in which the pilot was found to have a COHb level of 24%, the Senior Coroner for Buckinghamshire raised a number of concerns with the CAA regarding exposure to CO[64]. The CAA responded[65] that the potential for CO contamination in small aircraft is addressed through regulations that concern design, maintenance and operation of such aircraft. While N264DB was subject to FAA regulations, the CAA made the following comments with regards to aircraft registered in the UK:

> '***Aircraft Design.*** *The European Union Aviation Safety Agency (EASA) has oversight of the design requirements for aircraft designed under code CS-23 (Small Light Aircraft), which contain specific requirements on cockpit contamination prevention measures. The codes address the required levels of ventilation, the maximum acceptable CO content in the cockpit and the design of heating systems (notably exhaust-related heat exchangers) with a view to preventing CO contamination in the cockpit. The codes do not require CO detectors to be fitted as part of the design. Similar design requirements exist in the United States, which is the primary source of general aviation types.*
>
> ***Maintenance****. Maintenance (Continuing Airworthiness) requirements and recommendations in the UK provide that aircraft exhaust systems are to be inspected in accordance with the manufacturer's instructions. In the UK, there are two publications of specific relevance to this topic. CAA Publication (CAP) 562*[66] *Leaflet B-190, CO Contamination provides generic expectations for maintenance-related measures which aim to minimise the*

63 AAIB Bulletin EW/C2017/11/02, mid-air collision, G-WACG and G-JAMM.
64 https://www.judiciary.uk/wp-content/uploads/2019/08/Jaspal-Singh-Bahra-2019-0160.pdf [accessed February 2020]
65 Civil Aviation Authority response to a report on action to prevent other deaths pursuant to Regulation 29 of the Coroners (investigations) Regulations 2013.
66 CAP 562 *Civil Aircraft Airworthiness Information and Procedures.*

> *likelihood of such occurrences. It addresses the nature and effects of carbon monoxide, the causes of contamination, the importance of routine inspections and means of testing for contamination.*
>
> *CAP 747[67], Generic Requirement (GR) No. 11 covers potential CO contamination from combustion heaters, which are only fitted to a relatively small number of light aircraft. GR No 11 addresses servicing and overhaul requirements intended to detect CO contamination.'*

The CAA explained that some manufacturers have issued type-specific information that has been mandated by the responsible aviation authorities in the form of 'Airworthiness Directives'. They also explained that the new European light aircraft maintenance requirements, proposed for adoption in late 2019 (Part M Light), would be expected to contain a requirement in the Minimum Inspection Programme[68] to: '*Inspect Cabin Heat Exchanger for improper condition and function. For exhaust heat exchanger check CO-Carbon monoxide concentration.*' With regard to aircraft operations, the CAA wrote:

> ***'Operation.*** *In the UK, the 'Winter Flying' Safety Sense Leaflet contains information on the use of 'spot-type' passive indicators. Such devices are small, widely-available and relatively inexpensive. They can be attached to a wall or panel in the cockpit and do not need to be professionally installed.*
>
> *There are a range of active CO detectors available that use audible, visible or vibration warnings when pre-determined CO levels are exceeded. These have the notable advantage of actively engaging the pilot's attention and are accordingly more likely to be more effective than the 'spot-type' indicators.*
>
> *CO detectors may be fitted to UK-registered aircraft as 'standard changes' under the provisions of CS-STAN[69] (for EASA aircraft) and CAP 1419 (for non-EASA aircraft). This removes the need for direct authority involvement, allowing equipment to be installed without the associated time and costs.*
>
> *CO detectors are not mandated for general aviation aircraft, as from an initial design viewpoint, the requirements for the certification of the aircraft are such that the system design should minimise the*

67 CAP 747 *Mandatory Requirements for Airworthiness*.
68 At the time of this report, the draft legislation for the EASA Minimum Inspection Programme did not include a requirement to pressure test the exhaust, but it did call for a carbon monoxide check of the cabin heater system.
69 Certification Standard.

likelihood of CO contamination, but the maintenance of sometimes notably highly-utilised airframes and/or their ageing systems means that contamination can occasionally take place. The more widespread use of CO detectors is thus currently down to the pilot/owner's discretion'.

The CAA concluded:

'The Regulation 28 report to prevent future deaths has provided an opportunity to review available material on CO contamination avoidance. Notwithstanding the measures already in place and those expected in the near future, the CAA will consider the merits of additional information on best practice CO contamination avoidance in a 'Safety Notice' publication. To this end, the CAA will consult with members of the relevant stakeholder forum, the AOPA Maintenance Working Group, in making this decision by the end of the third quarter of 2019. If a decision be made to publish a Safety Notice, this is expected to take place by the end of 2019.'

1.18.1.10 EASA actions to address the risk of CO poisoning.

EASA acted to address the risk of CO poisoning as follows:

- In June 2010, EASA released Safety Information Bulletin (SIB) 2010-19 that highlighted the importance of properly inspecting and maintaining exhaust mufflers.
- In July 2015, EASA issued Certification Standard (CS-STAN) CS-SC107a which allows, under certain conditions, for the installation of CO detectors, either as panel-mounted devices or by a semi-permanent installation of 'lifesaver' badges held in place by adhesives. This CS-STAN was republished in March 2017 and April 2019.
- In March 2018, EASA promoted the use of CO detectors through a safety promotion 'Sunny Swift[70]'
- On 27 January 2020, EASA issued SIB 2020-01, *Carbon Monoxide (CO) Risk in Small Aeroplanes and Helicopters[71].* The SIB made recommendations on how to: avoid CO exposure; be actively warned if there is CO exposure; and how to react in case of CO exposure. The SIB stated: '*At this time, the safety concern described in this SIB is not considered to be an unsafe condition that would warrant either an Airworthiness Directive*

70 https://www.ease.europa.eu/newsroom-and-events/news/sunny-swift-co-intoxication [accessed February 2020]
71 https://ad.easa.europa.eu/blob/EASA_SIB_2020_01.pdf/SIB_2020-01_1 [accessed February 2020]

(AD) action under Regulation(EU) 748/2012, Part 21.A.3B, or a safety directive action under Commission Regulation (EU) 965/2012. Annex II, ARO.GEN.135C'[72].

1.18.1.11 Engine manufacturer's best practice on inspecting exhaust systems

The engine manufacturer issued Service Bulletin SB10-1A on 28 January 2010 providing guidance on inspecting the exhaust and turbocharger system. The Service Bulletin was applicable to the engine fitted to N264DB. The information in the Service Bulletin was subsequently incorporated into the engine manufacturer's M-0 Maintenance Manual (standard practice), which was issued on 15 April 2016. Extracts from this manual relevant to the inspection of the exhaust system are at Appendix D.

The guidance recommended the inspection and tests that should be carried out at the Annual inspection / 100-hour maintenance. Of note, the guidance recommended that:

- The system should be pressure tested by applying air at a pressure of 5 psi to the exhaust tailpipe and using soapy water to check for leaks.
- The V-band clamps should be removed and inspected, which would entail the removal of the tail pipe / heater muff.

While the engine manufacturer's guidance (Appendix D) was to inspect the heat exchanger joints and seams, it did not explicitly advise that the shroud around the exhaust tailpipe should first be removed (although the shroud was removed during the last two Annual inspections carried out on N264DB). Without removing the shroud, it would not be possible to check for damage on the outside of the tailpipe, or to apply soapy water to check if air was leaking from the tailpipe in this area.

The PA-46-310P aircraft maintenance manual made no specific references to the engine manufacturer's guidance regarding the inspection and testing of the exhaust system, nor did it specifically require the shroud to be removed as part of the inspection.

The engine manufacturer stated that it was not aware of any operational issues with the exhaust heater muff installed in the Piper PA-46-310P aircraft. It considered that a qualified aircraft mechanic following the inspection instructions outlined in the M-0 Maintenance Manual should be able to identify any potential unairworthy condition.

72 For a definition of 'unsafe condition', see AMC 21a.3B(b) to Part 21 in EASA ED Decision 20013/1/RM. Available: https://www.easa.europa.eu/sites/default/files/dfu/decision_ED_2003_01_RM.pdf [accessed February 2020]

1.18.1.12 FAA action relating to CO detectors

On 5 June 2009, the FAA produced a Technical Standards Order[73] giving information on the minimum performance standards for a CO detector to be fitted in the cabin of GA aircraft.

On 17 March 2010, the FAA issued a Special Airworthiness Information Bulletin (SAIB) (CE-10-19 R1) to advise owners and operators of GA aircraft on the need to inspect 'properly' and maintain the exhaust system to prevent leakage of CO into the cabin and to install commercially available CO detectors in the cabin. The FAA stated in this document that *'they did not consider that at this time there was an unsafe condition*[74] *that required an airworthiness directive'.*

1.18.1.13 Transport Canada Airworthiness Directive

On 31 August 1992, Transport Canada (TC) issued Airworthiness Directive (AD) CF-90-03R2. This AD mandated a detailed inspection of exhaust-type heat exchangers ('mufflers') used as a source of cabin and cockpit heat. The initial inspection was to be repeated at intervals not to exceed one year or 150 flight hours.

Unlike TC, the FAA, EASA and CAA have not issued ADs stipulating how inspections and tests on the exhaust system should be carried out.

1.18.1.14 Aircraft CO detectors

CO detectors designed to be carried in, or permanently installed on aircraft are commercially available. CO detectors are also installed as standard equipment on new aircraft by several light aircraft and helicopter manufacturers. These detectors provide an aural and visual warning when CO levels exceed a specified level.

1.18.2 Flying at night

Night flying requires a combination of instrument and visual flying skills. On a clear moonlit night, over a well-lit built up area and with a clearly defined horizon, pilots may be able to use a high proportion of visual flying techniques. However, when flying below cloud cover or on a dark night over unlit areas, pilots must rely mostly on accurate instrument flying. There are a range of visual illusions that can affect a pilot at night such as flicker vertigo, relative-motion illusion, reversable perspective illusion and false horizons caused by stars or ground lighting. The range of vestibular illusions that

73 Technical Standard Order TSO-C48a effective 05/06/09.
74 Unsafe condition is detailed in 14 Code of Federal Regulations Part 39.

are most often associated with instrument flying also apply when flying at night and may be even more powerful when there are few, if any visual clues available to the pilot.

Spatial orientation is the ability of human beings to orientate themselves within three dimensions against the surrounding environment. It requires the use of multiple sensory systems such as sight, hearing, pressure and touch as well as the vestibular system. The system is not infallible and flying stretches it to its limits and sometimes beyond. Visual and vestibular illusions can cause the pilot to lose spatial orientation in flight, especially when visual references are limited. This loss of spatial orientation can lead to a loss of aircraft control. Although humans have evolved to accept what their internal spatial orientation systems are telling them, instrument flying skills allow pilots to manage the inherent limitations of their internal perceptions by trusting and relying on flight instruments for orientation.

1.18.3 CAA Review of General Aviation Fatal Accidents

CAP 667, *Review of General Aviation Fatal Accidents 1985-1994*[75], discussed the major types of GA fatal accidents, including loss of control (LOC) in IMC. The report found that:

- ‘*Three quarters of the pilots involved were attempting to fly in IMC when not qualified to do so (no IR or IR(R)).*
- *More than two thirds of the pilots were flying outside the privileges of their licence, often leading to structural break-up.*
- *Almost two thirds continued flight into adverse weather, and more than half were thought likely to have suffered from disorientation.*
- *Almost a quarter experienced some kind of technical failure, thus distraction was likely.’*

75 http://publicapps.caa.co.uk/docs/33/CAP667.pdf [accessed February 2020]

2. Analysis

2.1 The flight from Nantes

2.1.1 Meteorological conditions

The weather forecast showed a cold front moving through overnight, preceded by scattered, sometimes heavy showers. Although the flight occurred ahead of the cold front, the rainfall radar reviewed after the flight showed numerous showers in the area north of the Channel Islands on the planned route.

The lack of ambient light and the weather conditions meant that the pilot would have had to rely predominately on the aircraft instruments for orientation. Night flying presents pilots with difficulties in identifying weather ahead of the aircraft. The lack of moonlight and horizon on this flight would have made it difficult for the pilot to avoid inadvertent penetration of weather and clouds.

A range of illusions can affect pilots when flying at night and / or with sole reference to aircraft instruments. These illusions can rapidly cause a loss of spatial orientation which can lead to a loss of control of the aircraft. The most effective way to counter these risks is to trust the information given by the aircraft instruments ahead of internal feelings about orientation, and this requires effective instrument flying skills. While the pilot held a valid IR(R), it was considered unlikely that he had been training or practising his skills since his last renewal in May 2017 because his recorded flying had been single pilot operating under VFR. Instrument flying is a perishable skill and regular practice is required for a safe standard to be maintained. Consequently, with an apparent lack of recent practice in instrument flying, the pilot's skills may have been significantly degraded.

N264DB was flying above the forecast freezing level. Had it entered cloud, it is possible that it may have started to accumulate ice. The aircraft was equipped for flight in icing conditions and the forecast was for only light to moderate icing conditions. Pilots flying in the area at the time of the accident indicated that they encountered little or no icing at the altitudes N264DB was operating.

2.1.2 Qualifications of the pilot

The pilot held an EASA PPL, and an FAA PPL issued on the basis of his EASA licence. To operate N264DB between France and the UK, the pilot was required to use his FAA PPL because of FAA restrictions in Part 61. The FAA licence relied upon the validity of his underlying EASA PPL, but the SEP rating on the EASA licence had expired. Legal opinion from both EASA and the CAA confirmed that the lack of a valid SEP rating and night qualification meant that the pilot was not qualified to fly the aircraft at the time of the accident.

The pilot's FAA licence did not specifically contain a day-only restriction, and the instructor who completed the pilot's differences training for the PA-46 erroneously signed the pilot's logbook as qualified pilot-in-command day and night. This may have led the pilot to wrongly believe he was qualified to fly at night on his FAA licence. However, both the CAA and EASA were clear that a FAA piggyback licence cannot grant a pilot qualifications or validity that do not exist on the underlying EASA licence.

The timing of the initial flight plan suggested that the pilot may have initially believed that the flight was to return during the day on 21 January 2019. Subsequent refiling of the flight plan, and communications between the pilot and third parties in both Cardiff and Nantes, showed that he was aware of the later flight time by the afternoon of 20 January 2019.

As a PPL holder, the pilot was not permitted to be remunerated for the flight, yet there was significant evidence to show that he was expecting to be paid. Payment brings with it some pressures for a flight to be completed so that the fee will be paid and, perhaps, to realise the opportunity to secure work in the future.

The CAA maintains a database of the licence details and qualifications of all pilots who hold a UK-issued flying licence as required under EASA Part ARA. GEN.220. As the accident pilot's licence and logbook were not recovered from the wreckage, the database information was expected to be important in establishing his qualifications. It became clear during this investigation, however, that the CAA database for the pilot of N264DB was incomplete and contained numerous errors. The pilot had scanned a copy of his licence onto his laptop, which the investigation was able to access, but without this copy erroneous conclusions might have been reached about the pilot's qualifications and entitlements. This mismatch between database records and a pilot's licence is not unique, and previous AAIB investigations have encountered similar discrepancies. Although the authoritative document is the licence, the competent authority, in this case the CAA, should maintain accurate information as required by EASA regulation. Therefore the following Safety Recommendation is made:

Safety Recommendation 2020-005

It is recommended that the Civil Aviation Authority ensure that the system in place to meet the requirements of EASA Part ARA. GEN.220 is effective in maintaining accurate and up-to-date records related to personnel licences, certificates and ratings.

2.1.3 Basis of the flight

N264DB was permitted to operate in accordance with Part 91, which is intended for private use only. Neither the Trustor nor the individual who managed the aircraft held an AOC, and no permission had been sought or granted from the FAA or the CAA to allow the aircraft to be operated on a commercial basis. The pilot did not hold a commercial pilot's licence and, therefore, was not permitted to receive payment for the flight.

Air Taxi or Air Charter flights are commercial operations, and regulatory safety standards are more stringent than for private flights. These standards include: more highly qualified pilots whose competence is checked more frequently; more stringent airworthiness requirements for aircraft; and more operational and engineering procedures to support operations. For example, if N264DB had been operating in accordance with Part 135, it would have been mandatory for the heater muff to have been pressure-tested. The effect of more stringent measures is to reduce the risk to those using commercial services.

Because N264DB was not being operated in accordance with safety standards applicable to commercial operations, the risk-reduction measures above were not in place, and this manifested itself in the flight being operated under VFR at night in poor weather conditions despite the pilot having no training in night flying and a lack of recent practice in instrument flying.

Evidence presented to the investigation from multiple sources suggested that the use of 'grey charters' could be relatively common and widespread, although, due to the nature of the activity, it can be difficult to determine the level accurately. In addition to being subject to increased risk, present because some of the regulated safety standards may not be applied, these flights may also be uninsured. The Air Charter Association recommends steps that passengers can take before hiring an aircraft to satisfy themselves that it is licensed for commercial operations.

The CAA takes a three-pronged approach to the regulation of such flights. Firstly, it seeks to educate those who may use such flights through leaflets, posters and public campaigns. Reducing demand for unlicensed services supports legitimate aviation and, thereby, increases the proportion of the travelling public receiving the benefit of appropriate safety margins. Secondly, the CAA offers support to those who wish to operate legally but have not done so due to a lack of knowledge or understanding of the regulations.

Finally, the CAA seeks to catch and prosecute those who are involved in illegal or unlicensed activity. The CAA and other agencies within the UK work closely together to share intelligence and target resources, but due to the nature of this activity it can be challenging to detect. The wider legitimate aviation community can provide vital intelligence to assist the CAA and other agencies to reduce such activity. The public can report concerns through the CAA website and be protected as Whistle-blowers if required.

Safety action

Following this accident, the CAA developed a campaign to raise awareness of unlicensed charter flights, including publishing a Leaflet, *Legal to Fly,* to inform passengers about flying safely in light aircraft and business jets. The leaflet is in Appendix C.

2.2. Final manoeuvres

2.2.1 Pilot's use of the autopilot

The autopilot and flight director system had an intermittent fault whereby the autopilot disconnected without manual intervention and in July 2017 they were placarded as inoperative. There was no record of the fault having been rectified and the investigation was given conflicting information on whether a placard was actually fitted when the pilot flew to Cardiff to collect the passenger for the outbound flight to Nantes. Analysis of the radar data, however, in particular the accuracy with which the pilot maintained heading and altitude, suggested that as the aircraft approached Guernsey the pilot was flying with the autopilot engaged and with the HDG and ALT modes selected. Shortly afterwards, at 2002:10 hrs, when the pilot initially manoeuvred the aircraft to "MAINTAIN VMC", the right turn was consistent with the autopilot being used because the bank angle was calculated to be about 22°, the autopilot's maximum bank angle. During the left turn that followed, the bank angle exceeded the limit of the autopilot and it is therefore likely that the aircraft was being flown manually by the pilot, either with the autopilot disengaged or using the CWS function (with the autopilot engaged). Following the left turn, the aircraft's course and altitude stabilised, suggesting that the autopilot was engaged again.

At 2012 hrs, when the aircraft was about 11 nm north of Guernsey, ATC gave permission for the pilot to descend below FL50, and this was the last communication with him. Shortly afterwards (Figure 12), a right, followed by left turn was flown, during which the bank angle reached about 56°, while the aircraft descended, climbed and then descended again at a vertical speed of about 5,000 fpm. This series of turns lasted about 90 seconds, and it was likely that they were flown to remain in, or regain VMC, but they resulted in a flightpath that was unstable and inconsistent with normal cruise flight or with use of the autopilot. The investigation concluded that the aircraft was being flown manually during this period, which was shortly before it entered the final descending turn to the right.

It was not possible to ascertain whether, in the manoeuvring prior to or during the final turn, the pilot deliberately flew manually or whether the autopilot disconnected unexpectedly forcing him to do so. If the latter, it is possible that the pilot became distracted in trying to re-engage the autopilot. The CAA study into LOC accidents in IMC reported that, in almost a quarter of accidents considered, distraction was likely because there had been a technical failure.

2.2.2 Final descending turn

The simulations of the final descending turn were based on radar data which was considered valid. When the aircraft entered the final 180° turn, the simulations showed the bank angle increasing to about 30° right, at which point there was a pause of a few seconds. This angle of bank equates to a rate of turn of approximately 3.7° per second, about 20% higher than in a rate one turn.

After the pause, the bank angle started to increase and the nose of the aircraft dropped, causing the aircraft's airspeed to increase quickly (at an average rate of about 1.4 kt per second). By the time the aircraft had descended from about 4,100 ft to 2,700 ft, which took about 23 seconds, the bank angle was about 90° right and the estimated airspeed was 235 KIAS, 32 kt above V_{NE}. The high bank angle and speed were so far from normal parameters that they indicated control of the aircraft had been lost.

Both simulations showed that the aircraft then started to roll to the left towards wings level. Given that both simulations suggested the same roll to the left at the same time, it was concluded that the aircraft itself probably also rolled left, which would have required a control input ie the control wheel had to be rotated left.

From this point, the estimated normal loads of the two simulations diverged due to the different potential flightpaths. If the aircraft had continued to descend towards the sea, the peak estimated normal load would have reached 5.6 g as the aircraft rolled towards wings level. Alternatively, if the aircraft had pitched up to climb from 1,600 ft towards 2,300 ft, a normal load of 11 g would have been required. The simulation was based on an indestructible-aircraft model, and the actual aircraft is likely to have exceeded its structural limits before such a pull-up manoeuvre could be completed. If exceeding structural limits did lead to an in-flight breakup, unpredictable pressure effects might have caused the aircraft's transponder to report an incorrect altitude. This introduced the possibility that the aircraft did not actually climb to the 2,300 ft its transponder reported, but instead broke up at a lower altitude.

2.2.3 In-flight breakup

2.2.3.1 Structural damage to the aircraft

Analysis of the damage to N264DB was consistent with the aircraft impacting the water at high speed in an inverted, left wing low, nose high attitude. The left wing showed evidence of failing due to downward bending force. The right wing had failed in the same area as the left wing, but it was not possible from the video evidence to determine the direction in which the right wing failed.

The lack of damage to the propeller and the front of the aircraft, and the extensive damage to the upper surfaces of the wings and fuselage, were evidence that the aircraft did not enter the sea in an upright attitude consistent with controlled flight. The damage to the aircraft also indicated that it was not in a spiral dive or a spin when it struck the sea.

Neither of the outer sections of N264DB's wings nor the empennage were found at the accident site. This indicated that either an in-flight structural break-up occurred, or these parts broke off when the aircraft struck the sea and became separated from the main part of the wreckage by the fast tidal flow.

The damage to N264DB showed several similarities with the findings of the NTSB special investigation into in-flight structural failures of four PA-46-310P (Malibu) and one PA-46-350P (Mirage):

- Three of the aircraft in the study were found in an inverted attitude with the fuselage 'flattened'. It was not possible to ascertain the attitude at impact for two of the aircraft. N264DB entered the sea in an inverted attitude.
- In all of the accidents in the study, sections of both wings had failed in flight, with the failures mostly occurring in the area of the wing spar splice joint. The failure of the wings on N264DB occurred at the same location.
- In all of the accidents in the study, parts of the stabiliser and fin had separated from the aircraft while still in flight. These parts were also missing from N264DB.

It is probable, therefore, that N264DB experienced an in-flight structural failure rather than breaking up as the aircraft struck the sea. After such a failure, the aircraft would have descended rapidly and not travelled far laterally. This was consistent with the location of the wreckage, which was very close laterally to the last secondary and subsequent primary radar positions.

2.2.3.2 Loads on the aircraft

The NTSB's special investigation determined that the structural damage in the previous accidents was typical of overstress (overload). As a result of this finding, the aircraft manufacturer carried out a structural loads review of the wings and empennage. The review concluded that a minimum of 7.7 g would have been required to cause the wings to fail, which was well beyond the design certification requirements.

The simulation suggested two possible explanations for the breakup of the aircraft during the final manoeuvre:

- The transitory loading approached 11 g when the aircraft pulled up, resulting in the structural failure of the wings.
- The aerodynamic loads, resulting from the nose-up control input with the aircraft flying substantially above V_A[76], caused the structural failure of the elevator and horizontal stabiliser.

Had the wings failed as a result of a high positive loading, they would have failed in an upward direction possibly damaging the upper fuselage. Given the extensive damage to the upper fuselage when it impacted the sea, it was not possible to establish if any of the damage had been caused by the wings. However, the left wing failed due to bending in a downwards direction, which was inconsistent with the first possibility.

If the elevator and horizontal stabiliser failed when the aircraft was flying at a relatively high speed, the change in the balance of forces would have pitched the aircraft nose-down rapidly causing a wing to fail due to an excessive bending force. In some previous accidents where the horizontal stabiliser failed first, it was noted that one wing failed as a result of an upwards force and the other as a result of a downwards force.

It was concluded that an abrupt nose-up control input, at a speed substantially greater than V_A, led to aerodynamic loads on the elevator and horizontal stabiliser which were sufficiently in excess of their design limits to cause their structural failure. Following the failure of the horizontal stabiliser, the aircraft would have pitched rapidly nose down and the subsequent aerodynamic loading would have caused the wings to fail at the splice joints.

76 Design manoeuvring speed: the speed above which full or abrupt control movements are not permitted.

2.3 Airworthiness of N264DB before departing from Cardiff

At the time of the accident, N264DB had all the necessary airworthiness documentation required to operate in accordance with 14 CFR Part 91. Maintenance records for the previous three years showed that the aircraft had undergone the scheduled maintenance required by the FAA and had regularly been certified as being in an airworthy condition by two FAA IAs who worked at different maintenance organisations.

A review of the worksheets and Certificate of Release to Service showed that a considerable amount of rectification work had been carried out on the aircraft in the 13 months and approximately 65 flying hours prior to the accident flight. This included a new hydraulic pack and turbochargers as well as work to the engine, flaps and undercarriage.

The last Annual / 100 hour scheduled maintenance was completed approximately seven weeks and 11 flying hours prior to the accident flight and identified no deficiencies with the aircraft. The altimeter and transponder required a calibration test but could still be used providing the aircraft did not operate under IFR in controlled airspace. The individual who managed the aircraft stated that he was unaware of any deficiencies or faults on the aircraft prior to the outbound flight from Cardiff to Nantes.

At Cardiff Airport prior to the outbound flight, the pilot made no mention of any technical problems with the aircraft. Neither did he tell the three individuals in the UK, who he contacted from Nantes over the weekend, that there had been any technical problems with the aircraft before it left Cardiff.

From the available evidence the investigation concluded that, prior to departing Cardiff, N264DB met the required airworthiness requirements and had no known technical faults that would have prevented it from departing on the flight to Nantes.

2.4 Technical faults at Nantes

At Nantes, the pilot informed a number of individuals about four potential technical problems that had occurred on the aircraft after he departed from Cardiff. These were an engine oil leak, a loss of brake pressure, a spurious stall warning, and a ‘bang’ concurrent with a low-level mist sensed in the airframe. Over the weekend of 19 January 2019, the pilot discussed some of these problems with the individual who managed the aircraft, a UK based FAA IA, a mechanic at Nantes and Witness A. The pilot was also seen to remove the upper engine cowling and undertake an engine ground run before the return flight to Cardiff on 21 January 2019.

From photographs taken by the pilot, the engine oil leak was assessed as being no more than a 'weep' from the top of the air / oil separator. The pilot did not report a loss of engine oil. The radar data showed that the aircraft was operating at cruise speed until the loss of control and the pilot gave no indication during his last radio communication that he had an engine problem. Therefore, the oil leak was not considered to have been a factor in this accident.

The mechanic who checked the brakes in Nantes was satisfied that they were "fine", though the right pedal felt firmer than the left. Any brake problem was unlikely to have manifested itself until the landing at Cardiff, so the brake fault was not considered to have been a factor in this accident.

The pilot pulled the circuit breaker for the stall warning system after landing at Nantes because it was operating continuously. It was not known if this fault was rectified or if the circuit breaker was reset prior to the accident flight. During the initial loss of control, the aircraft was not in a stalled condition and therefore a stall warning would not have been triggered. While a stall warning might have been triggered during the final pitch up, it would have been coincidental with the structural failure.

It was not possible to establish the reason for the single bang and the mist the pilot sensed in the airframe. The pilot made no mention of the low mist to the FAA IA. He indicated that he had experienced the low mist before, but the investigation could identify no other individuals who had experienced it. To see a low mist, the pilot would either have had to look down into the footwell or rearwards into the cabin. Conditioned ram air would have been blowing out of the foot warmers onto the pilot's feet and it is possible that what he sensed was a change in temperature of this air. The location where this event occurred was uncertain with the pilot telling a witness that it occurred mid-channel and the FAA IA that it occurred on the approach to Nantes. What was consistent was that the noise startled the pilot, whose immediate action was to check the engine, which continued to operate normally. The following causes for the loud bang and / or mist were considered:

- *Bird strike*

  The pilot, who inspected the aircraft at Nantes, made no mention of any evidence of a bird strike.

- *Failure of a turbocharger turbine*

  The pilot reported that he checked the engine performance in the air immediately after the event and while the aircraft was on the ground at Nantes, and it operated normally. Should a

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turbine in one of the turbochargers become detached, some of the exhaust gas that would normally pass through the remaining serviceable turbocharger would pass through the common duct and into the turbine section of the turbocharger with the missing turbine. The result would be that the engine would not achieve maximum boost pressure or rpm. This was observed by the NTSB who established during testing that failure of a turbocharger turbine would affect the maximum boost and rpm of the engine and would therefore be noticeable.

- *Mechanical failure of the engine*

  The engine continued to operate normally during the remainder of the flight. At Nantes, the pilot visually examined the engine with the top cowling removed and carried out full power ground runs, which were satisfactory.

- *Cabin pressurisation*

  It was not possible to establish if the pressurisation controls had been correctly set or the outflow valve had stuck out of position. A sudden release of pressure through the outflow or safety valve, or a seal unseating, might have caused the noise. The resulting change in pressure, under the right atmospheric conditions, could then cause a mist to appear, which would be dispersed by the airflow through the cabin.

- *Change in external atmospheric conditions*

  The possibility that changes in the atmospheric conditions might have generated some misting as the ram air entered the cabin through the low-level vents was considered. However, this would not have generated a noise, and the manufacturer, other operators and maintenance organisations had not heard of this occurring previously on the PA-46.

- *Undercarriage settling*

  The undercarriage is held in the UP position by hydraulic pressure. If the hydraulic pressure drops below a minimum, then the electric hydraulic pump operates to restore the pressure. The noise of the pump is distinctive, and the pump is located at the back of the cabin inside the pressure vessel, and therefore the pilot would have described the noise as coming from behind him.

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- *Skin popping*

  Under certain pressure or temperature conditions, the skin on the flat lower part of the fuselage, below the seats, can 'pop' occasionally. This occurs because, under certain conditions, small changes to the skin can cause it to buckle.

- *A failure of part of the exhaust system or other engine component*

  The pilot removed the cowlings at Nantes and examined the engine. He subsequently made no mention of having found anything unusual. Moreover, if the mist had been smoke from the exhaust entering the cabin then it should have been present for the remainder of the flight.

- *Passenger's baggage*

  Some of the passenger's luggage might have been in the baggage hold located between the engine and cockpit, and it is possible that something in one of his bags made the loud noise. The pilot made no mention of damage to the passenger's bags or the baggage hold.

As the investigation was unable to determine the cause of the 'bang' and possible mist on the previous flight, it could not be determined if it was a factor in this accident.

2.5 The flow of CO into the cabin

The level of CO in the blood of the passenger led the pathologist to conclude that he would have been deeply unconscious when the aircraft struck the water. Video footage of the passenger passing through the airport security at Nantes did not suggest that he was suffering from the effects of CO poisoning, and no witnesses commented adversely on his behaviour prior to the flight. It was therefore concluded that the passenger's exposure to a high level of CO occurred during the accident flight.

The ambient air temperature during the cruise was around 0°C, and to ensure the cabin was at a comfortable temperature the cabin heat control would have been open. With the cabin conditioning controls set correctly for either pressurised or unpressurised flight, air under pressure would have entered the cabin through the floor level vents and the windscreen demister. Providing the pilot had turned the circulation fan ON, air from the back of the cabin would have been recirculated through the adjustable eyeball vents located at each seat. This air would then have passed out of the cabin

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through the outflow or safety valve situated behind the rear seats where the passenger was sitting.

For unpressurised flight the pilot should have set the CABIN PRESS control for unpressurised flight and the CABIN DUMP switch in the ON position. This would have allowed condition ram air to enter the cabin through the vents and to exit the cabin through the safety valve. However, if the CABIN DUMP switch had not been selected ON then the safety valve would have remained in the closed position. In this situation, the airflow through the cabin would be dependent on the position of the outflow valve. This valve would be controlled by the cabin altitude that had last been set on the altitude controller, and the differential pressure between the cabin and ambient pressures.

The concentration of CO around the cabin of N264DB would have been affected by the flow and circulation of the contaminated air, which would have been dependent on how the pilot set the controls and whether individual seat vents (eyeball) had been turned on. Due to the extensive damage to the cockpit area and instrument panel that occurred during the accident sequence, the position of these controls after the accident was not a reliable indication of their in-flight setting.

Possible causes of CO entering the cabin

The following causes were considered that might potentially explain how CO entered the cabin or why the passenger had such high levels of COHb:

- *The COHb in the passenger developed after the accident*

  Medical advice was that COHb cannot be produced naturally in a body after death.

- *Cabin fire*

  The pilot did not report fire or smoke during his last radio call, there was no evidence in any of the underwater footage of a fire having occurred, and the post-mortem report on the passenger showed no evidence of a fire inside the cabin.

- *Fire in forward baggage compartment*

  Some of the passenger's luggage was in the forward baggage compartment located between the forward pressure bulkhead and the engine firewall. The ventilation and pressurisation pipes pass through this area before discharging the conditioned air into the cabin. CO from a fire in the baggage compartment should not pass through the pressurised bulkhead. There was no evidence on the underwater videos of a fire having occurred in this area and no mention from the pilot of smoke or fumes entering the cabin.

- *Gas from the engine exhausts entered the cabin through seals and gaps*

  The cabin is designed to be pressurised and therefore, even when unpressurised, it will be more resistant to this type of gas pathway than aircraft designed to be unpressurised. The accident flight lasted for approximately one hour and the aircraft flew for two hours on the outbound flight without any reports that either the pilot or passenger felt unwell. The extensive damage to the fuselage meant that it would not have been possible to identify failed seals and small gaps that were present before the accident occurred.

- *Exhaust gas leak across the turbocharger*

  For this to be the source of CO, the cabin would need to be pressurised and exhaust gasses would need to leak along the shaft between the turbocharger turbine and compressor before entering the bleed air system, which provides pressurised air to the cabin. The pressure difference across the labyrinth seals on the turbine shaft is such that with a worn or damaged seal, oil would leak outwards along the shaft into either the turbine or compressor rather than exhaust gasses leaking inwards along the shaft. Should exhaust gasses leak past the labyrinth seal on the shaft, they would be removed by the lubricating oil and vent to atmosphere through the oil breather. It is therefore unlikely that the CO would have entered the cabin by this route.

- *Leak from the exhaust system passing into the cabin.*

  Parts of the exhaust system might have leaked or failed allowing exhaust gasses to enter the engine compartment. For these gasses to have entered the cabin they would have needed to pass through the seals or cracks in both the firewall and the forward pressurisation bulkhead, which are separated by the baggage compartment. An inspection of the firewall and pressure bulkhead, which was carried out during the last Annual maintenance, identified no damage to either of these structures.

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- *Leak through nosewheel steering bellow assembly*

  Exhaust gasses from the engine compartment could potentially leak through the nosewheel steering bellows into the pilot's footwell. It is unlikely that gasses would be able to enter the cabin during pressurised flight. While there is a potential threat during unpressurised flight, the bellows and nosewheel steering controls were inspected during the Annual / 100-hour maintenance[77] and it is unlikely that they would have deteriorated sufficiently in the short time before the accident flight.

- *Internal failure of the Heat Exchanger*

  This failure mode would only occur when the aircraft was pressurised and would need two separate faults. CO from the exhaust gas would have to leak into the ram air; then the ram air in the heat exchanger would need to leak into the bleed air as it passed through the heat exchanger and into the cabin. The bleed air is at a higher pressure than the ram air, so if there was damage to the matrix in the heat exchanger the bleed air should leak into the contaminated ram air, which is then vented out of the right side of the aircraft. Therefore, this scenario was considered unlikely unless there had been significant damage to the matrix in the heat exchanger and the tailpipe heater muff.

- *Failure of the right turbocharger*

  This failure mode would only occur during unpressurised flight. If the turbine on the right turbocharger detached in flight, there would be a possibility that it could puncture the exhaust tailpipe allowing exhaust gases to enter the ram air system through the heater muff. However, where turbochargers have previously failed in flight, the turbine has left marks in the tailpipe but not punctured it. Testing by the NTSB during another investigation revealed that following the loss of a turbine the engine would lose all its oil in a matter of minutes. Moreover, a single turbocharger would not enable the engine to obtain maximum boost and rpm.

  A turbocharger failing in flight and puncturing the tailpipe might explain the loud bang and possible 'low mist' in the fuselage on the outbound flight to Nantes, providing the

77 PA-46-310P/350P Maintenance Manual 100 Hrs Interval Inspection, G. Landing Gear Group

damage to the exhaust was significant enough. As neither the pilot nor passenger exhibited symptoms of high levels of COHb on arriving at Nantes, failure of the turbocharger could not have occurred mid-channel on the outbound flight. If the failure occurred at a late stage in the outbound flight, and the engine kept running, the pilot would have noticed the loss of oil and lack of performance when he carried out his ground runs at Nantes. He told several individuals that the engine performance was satisfactory. If the turbocharger failed before the aircraft departed Nantes, the loss of oil would have resulted in the engine failing soon after takeoff. Therefore, a failure of the turbine on the right turbocharger could not have occurred before the aircraft departed Nantes.

During the accident flight, the performance of the aircraft based on the radar data did not suggest that the engine had lost power. The pilot would have been alerted by a low oil pressure warning light and seen the reduction of oil pressure on the gauge, but he made no mention of an engine problem to ATC. There was also no evidence of score marks in the part of the right exhaust visible on the underwater video. It was therefore considered unlikely that the right turbocharger failed during the accident flight.

- *Crack in the exhaust tailpipe*

  This failure mode could only occur if the aircraft was operating with the cabin unpressurised and the cabin heat ON.

  The pressure of the ram air passing through the heater muff is by design higher than the ambient pressure of the exhaust gas in the tailpipe. This is to ensure that in the event of damage or a crack in the tailpipe, ram air will leak into the tailpipe rather than exhaust gasses leaking into the ram air and then into the cabin. For exhaust gases to have leaked into the heater muff and pass into the cabin, there would have needed to have been a significant crack or damage to the tailpipe to allow the pressure of the ram air and exhaust gas to equalise. Given that there were no reports of the pilot or passenger feeling unwell on the outbound flight, this failure mode would have required a sudden deterioration in the exhaust during the later stage of the outbound flight or during the accident flight.

The exhaust system was last inspected during the Annual maintenance completed on 30 November 2018, 11 flying hours before the accident. Despite the requirement to inspect exhaust systems annually, there is evidence of these types of items cracking in service between inspections. The NTSB's Safety Recommendation to mandate the carriage of CO detectors was made following the failure of a heater muff (fitted to a different type of piston engine and aircraft) which failed six flying hours and three months after its Annual inspection.

Most probable cause of CO entering the cabin

From an assessment of the possible routes for CO having entered the cabin during the accident flight, the most probable cause was considered to be exhaust gasses leaking into the heater muff with the cabin heating selected ON. This would have required significant damage / disruption to have occurred to the tailpipe/ heater muff during the accident flight .

2.6 The loss of control

2.6.1 CO in the cabin

The pathologist considered that the passenger would have been deeply unconscious at the time of the accident and the pilot would have been exposed to similar levels of CO to the passenger. The toxicology results of the four occupants fatally injured in an accident involving a PA-28 showed that individual levels of COHb can vary between individuals occupying a compartment contaminated with CO. Although the available information did not allow a quantitative determination to be made, it is likely that the pilot was affected to some extent by the effects of CO poisoning.

2.6.2 Aircraft control during manoeuvring beginning at 2012 hrs

Four minutes prior to the accident, at 2012 hrs, the pilot was talking lucidly on the radio explaining that he was going to manoeuvre to avoid poor weather. This suggested that, if he had already been exposed to CO, the symptoms were at the lower end of the scale. The flightpath over the following 90 seconds was unstable and included high bank angles and rates of climb and descent inconsistent with normal cruise flight. There were four scenarios which might have accounted for this erratic flying:

- The pilot manoeuvred in this way deliberately, probably to avoid IMC or to regain VMC (having inadvertently entered IMC).

- The pilot was having difficulty in controlling the aircraft, probably while manoeuvring to avoid IMC or regain VMC. His lack of training in night flying and his lack of recent practice in instrument flying support this possibility because they are likely to have made him more susceptible to disorientation through visual and / or vestibular illusions.

- The pilot was beginning to suffer from the symptoms of CO poisoning, which were affecting his ability to control the aircraft.

- A combination of some, or all the scenarios above.

2.6.3 Aircraft control during the final turn

Shortly after the aircraft flightpath stabilised from this manoeuvring, the pilot entered the final turn, and it was likely that this turn was flown either to avoid IMC or to regain VMC. It was concluded earlier that the high bank angle and speed in that turn were so far from normal parameters that they indicated control of the aircraft had been lost. Considering the four scenarios in paragraph 2.6.2:

- It was unlikely that the pilot manoeuvred in this way deliberately to avoid poor weather because the flightpath was so extreme that it represented a greater risk than the weather he would have been trying to avoid.

- The CAA review of fatal LOC accidents in IMC showed that common factors were:

  – Pilots having no IR or IR(R).

  – Pilots flying outside the privileges of their licences.

  – Pilots flying outside limits, often leading to structural break-up.

  – Disorientation.

  – Distraction due to technical failure.

  It was likely, therefore, that the pilot's lack of training in night flying and his lack of recent practice in instrument flying were, in themselves, sufficient to increase the risk of loss of control while manoeuvring manually at night in the vicinity of poor weather.

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- It was likely that the pilot was by this stage suffering from the symptoms of CO poisoning to an extent that was inhibiting his ability to control the aircraft.

- It was concluded in paragraphs 2.2.2 and 2.2.3 that the end of the flight was marked by the aircraft rolling left and pitching upwards before breaking up. The roll left would have required the control wheel to be rotated left, and this motion might have been achieved by the pilot consciously or by him slumping onto the left side of the control wheel. The pitch up, however, would have required the control wheel to be moved rapidly aft, which would not have been possible if the pilot was completely unconscious. It appeared likely, therefore, that the pilot had at least some level of function at this point in the flight.

  The roll and pitch inputs on the control wheel were consistent with an attempt to recover the aircraft from its extreme attitude and rate of descent. If both inputs were made consciously, it was possible that the pilot regained some level of situational awareness and tried to recover the situation, albeit perhaps with excessive control inputs.

In summary:

- The pilot's ability to control the aircraft was probably impaired by the effects of CO poisoning, but he appeared to have some level of function at a late stage of the flight.
- The pilot's lack of training in night flying and recent practice in instrument flying is likely to have increased the risk of loss of control.

It was not possible to quantify the extent to which either factor contributed to events, but it was likely that the loss of control was made significantly more likely by the probability that the pilot was affected by CO poisoning.

2.7 Measures to reduce the risk of CO poisoning

N264DB had not been fitted with a CO detector with an active warning, but might have been fitted with a passive, spot (strip) detector, which could have been out of date. Even if it had been in date, its location in front of the right seat would have been of little use in alerting the pilot to the presence of CO when flying at night. Had the pilot been aware of the presence of CO, he would have been able to take measures to reduce the risk to himself and his passenger, such as those detailed in SIB 2020-01, but there is no requirement for GA aircraft to be fitted with a CO detector. Instead, it is the owner's / pilot's discretion as to whether they fit or carry a detector in the aircraft.

CO poisoning has been established as a factor in a number of accidents and serious incidents involving single engine piston aircraft. It is possible that there might have been more events, but detection is dependent on toxicology tests having been carried out, and the evidence of CO poisoning can be masked if there has been a post-crash fire. Mechanical evidence can also be destroyed in an accident. Assessing the true extent of the risk is also difficult because it relies predominantly on private pilots raising an occurrence report for a hazard that cannot be seen or smelt. It is also difficult to establish how often key components, such as heater muffs, are repaired or replaced because there is no requirement to collate this information.

The BEA and NTSB have made Safety Recommendations to aviation regulators to mandate the carriage of CO detectors, but they were not accepted, and the AAIB previously made a Safety Recommendation for the CAA to promote the carriage of detectors. While the CAA, EASA and FAA promote the carriage of CO detectors, many pilots still do not appear to understand the hazard and risk and at best only carry a strip or spot detector.

Regulators mandate two barriers[78] to prevent CO poisoning: initial design and regular in-service inspections. EASA has published a CS-STAN to facilitate the installation and replacement of CO detectors through standard changes, and many manufacturers have chosen to fit detectors to new aircraft. However, this is not a mandatory requirement and will not address the large fleet of ageing piston engine aircraft. The CAA, EASA and the FAA have all produced a specification for CO detectors and EASA has introduced a standard modification to make it easier for pilots to fit them to their aircraft; however, there is no requirement for pilots to do so.

There is considerable evidence that the second barrier, regular inspections, is not entirely effective. Not only is it difficult to carry out a thorough inspection of all the exhaust components in the crowded engine compartment, it is possible that a mechanic will miss a small crack or subtle signs of a leak. This was noted in Service Difficulty Reports where exhaust systems passed a visual inspection but then failed a pressure test. Moreover, corrosion and erosion occur from the inside of the exhaust system and can be difficult to detect without first dismantling the system.

Manufacturers and regulators have issued comprehensive advice and service bulletins on how to carry out an inspection of an exhaust system. However,

78 Safety barriers, or risk controls, attempt to prevent, control or mitigate undesired events.

for GA aircraft such as N264DB operating under the provision of 14 CFR Part 91 this advice is not mandatory, and it is for owners and their maintenance organisations to determine the depth and extent of the inspections. It would be difficult for regulators to mandate detailed inspections for the wide range of GA aircraft and exhaust systems currently in service. Moreover, it has been seen from other events that cracks and faults can initiate at any time. While periodic inspections can help reduce the risk, they will not catch every event.

CO poisoning is known in the UK as the 'silent killer' as the gas cannot be seen, smelt or tasted and its effects can lead to a reduction in performance, permanent injury or death. Even the minor effects of CO poisoning can have a fatal consequence when operating an aircraft. As the existing two barriers to prevent CO poisoning (design and inspections) are not always effective, there is a need for a third barrier to alert pilots to the presence of CO in the cabin in time to take effective action. Low cost warning devices are readily available, and their carriage is actively encouraged by the regulators. Regulators have also produced specifications for CO detectors with active warnings. Although the carriage of a CO detector is at the owner's and pilot's discretion, it is unlikely that passengers, pilots under training and individuals who use cost sharing websites understand the risk. Therefore, the following Safety Recommendations are made:

Safety Recommendation 2020-006

It is recommended that the Federal Aviation Administration require piston engine aircraft which may have a risk of carbon monoxide poisoning to have a CO detector with an active warning to alert pilots to the presence of elevated levels of carbon monoxide.

Safety Recommendation 2020-007

It is recommended that the European Union Aviation Safety Agency require piston engine aircraft which may have a risk of carbon monoxide poisoning to have a CO detector with an active warning to alert pilots to the presence of elevated levels of carbon monoxide.

Safety Recommendation 2020-008

It is recommended that the Civil Aviation Authority require piston engine aircraft which may have a risk of carbon monoxide poisoning to have a CO detector with an active warning to alert pilots to the presence of elevated levels of carbon monoxide.

2.8 Guidance in maintenance manuals

While the engine manufacturer produced guidance on how to examine its exhaust system, this guidance was not included or directly referenced in the aircraft manufacturer's 100-hour / Annual maintenance schedule. There was a warning in the introduction of the aircraft maintenance manual about consulting vendor publications, but there was no specific requirement in the 100-hour / Annual maintenance schedule for the PA-46-310P to pressurise the exhaust system to check for leaks.

During the Annual maintenance of N264DB, two separate maintenance organisations carried out a detailed visual inspection of the exhaust system which they believed was sufficient to establish its condition. A pressure test would only have been carried out if they were unable to visually examine all parts of the heater muff or there was evidence of damage or deterioration. Moreover, because the aircraft manufacturer's maintenance schedule (which they used) did not call for the exhaust system to be pressure tested, they believed they were only required to carry out a visual inspection. There was no AD for the exhaust system on the PA-46-310P to be pressure tested when operating in accordance with 14 CFR Part 91.

The following Safety Recommendation is made to direct maintenance organisations and mechanics to the guidance in the engine manufacturer's manual to pressure test the exhaust system during scheduled maintenance:

Safety Recommendation 2020-009

It is recommended that Piper Aircraft Inc. ensure that the 100-hour / Annual maintenance schedule for the PA-46 variants references the engine manufacturer's guidance, where available, on inspecting and testing the exhaust system.

Detailed advice is readily available on how to inspect exhaust system components and check for leaks using pressurised air and soapy water. The engine manufacturer in its guidance document advised: *'Inspect the heat exchanger seams, joints and transitions with a flashlight and mirror or a flexible borescope for physical damage, cracks, corrosion, and burn-through.'* While the shroud was removed on N264DB during the previous Annual maintenance, neither the aircraft maintenance schedule nor the guidance from the engine manufacturer explicitly specified that it should be removed as part of the inspection. Without first removing the shroud and any other jackets, it would be difficult to detect cracks, damage on the outside of the exhaust tailpipe, or leaks into the cabin conditioning system through the heat exchanger.

Safety Action

Following this accident, the engine manufacturer stated that it would:

1. Work with Original Equipment Manufacturers to determine the best way to convey the importance of thorough exhaust system inspections.

2. Review its maintenance and overhaul manuals to determine whether additional elaboration would increase the chance of a qualified mechanic finding a potentially unairworthy condition. It undertook to complete this review in order to have any amplifications implemented in the next FAA approved version of its Standard Practice Manual (M-0).

3. Conclusions

3.1 Findings

1. There was no evidence to suggest the pilot and passenger were not fit and healthy prior to the flight or that the pilot was not well-rested.

2. The pilot was operating on an FAA PPL issued on the basis of his existing EASA PPL and subject to the validity of its ratings.

3. The SEP rating on the pilot's EASA licence expired in November 2018 and he had no night rating, so he was not qualified to fly the aircraft at the time of the accident.

4. The pilot's PPL did not permit him to receive remuneration for flying, but he was to be paid a fee for the accident flight.

5. It is likely that the pilot felt some pressure to complete the return leg of the flight even though it would be at night and in poor weather.

6. The aircraft had valid Registration, Airworthiness and Release to Service Certificates, and the required scheduled maintenance had been completed.

7. The aircraft was operated in accordance with 14 CFR Part 91, *General Operating and Flight Rules,* and maintained in accordance with Part 43, *Maintenance, Preventive Maintenance, Rebuilding, and Alteration*.

8. The regulations under which the aircraft was operated and maintained permitted it to be used for private use only. No permission had been sought or granted which allowed the aircraft to be operated commercially.

9. The aircraft was not being operated in accordance with safety standards applicable to commercial operations.

10. The autopilot and flight director had been diagnosed as having an intermittent fault and should have been placarded as inoperative.

11. Just after 2012 hrs, a series of turns was flown over about 90 seconds, probably so that the aircraft would remain in, or regain VMC. During the turns, the flightpath was unstable and inconsistent with normal cruise flight or with use of the autopilot.

12. At 2016 hrs, the aircraft began a turn to the right and began to descend. As it descended through approximately 2,700 ft amsl, the angle of bank was approximately 90° and the airspeed was approximately 235 KIAS.

13. The aircraft attitude and speed were so far from typical values encountered in normal operations they indicated that the autopilot was not engaged and control of the aircraft had been lost.

14. At approximately 2016:30 hrs, as the aircraft descended below 2,700 ft, there was an abrupt nose-up pitch input when the airspeed was at least 100 kt above V_A, the speed above which full or abrupt control movements are not permitted.

15. During the subsequent pull-up manoeuvre, aerodynamic loads exceeded design limits and caused the structural failure of the elevator and horizontal stabiliser, followed by the structural failure of both wings at the splice joints.

16. The last secondary radar contact with the aircraft was at 2016:34 hrs.

17. The aircraft struck the sea in an inverted, left wing low, nose-high attitude.

18. The impact with the sea was not survivable.

19. There was no evidence of fire.

20. While the possibility of aircraft icing could not be discounted, it is unlikely that icing was a factor in the accident.

21. It could not be determined what caused the reported 'bang' and mist on the previous flight, and whether it was a factor in this accident.

22. The faults with the stall warning, brakes and oil leak reported by the pilot at Nantes were not a factor in the accident.

23. At the time of the accident, the passenger's blood had a very high level of COHb, and it was likely that the pilot was also affected to some extent by CO poisoning.

24. Although the level of COHb in the pilot's blood could not be determined, it was likely that his ability to control the aircraft was impaired during the later stages of the flight, thereby significantly increasing the likelihood that control would be lost.

25. The abrupt pull-up of the aircraft just before it broke up required the control wheel to be pulled aft, and therefore the pilot probably retained some level of function at this time.

26. The most likely reason for CO to have entered the cabin was a failure of the part of the exhaust tailpipe containing the heater muff, which allowed exhaust gas to mix with the ram air and enter the cabin through the cabin conditioning system.

27. The exhaust system, including the heater muff was visually inspected during the Annual maintenance 11 flying hours before the accident. In a different accident, a muffler has been known to fail six flying hours after inspection.

28. A pressure test of the heater muff was not carried out during the previous two Annual maintenance inspections. Under 14 CFR Part 91, the 100-hour / Annual maintenance schedule did not call for such a test to be carried out.

29. The 100-hour / Annual maintenance schedule did not directly reference the engine manufacturer's guidance on how to examine the exhaust system.

30. In-service inspections of exhaust systems do not eliminate the risk of CO poisoning.

31. There is no requirement for CO detectors to be carried on piston engine aircraft, although regulators advise pilots to do so.

3.2 Causal factors

1. The pilot lost control of the aircraft during a manually-flown turn, which was probably initiated to remain in or regain VMC.

2. The aircraft subsequently suffered an in-flight break-up while manoeuvring at an airspeed significantly in excess of its design manoeuvring speed.

3. The pilot was probably affected by CO poisoning.

3.3 Contributory factors

1. A loss of control was made more likely because the flight was not conducted in accordance with safety standards applicable to commercial operations. This manifested itself in the flight being operated under VFR at night in poor weather conditions despite the pilot having no training in night flying and a lack of recent practice in instrument flying.

2. In-service inspections of exhaust systems do not eliminate the risk of CO poisoning.

3. There was no CO detector with an active warning in the aircraft which might have alerted the pilot to the presence of CO in time for him to take mitigating action.

4. Safety Recommendations and Action

4.1 Safety Recommendations

The following Safety Recommendations are made in this report:

Safety Recommendation 2020-005

It is recommended that the Civil Aviation Authority ensure that the system in place to meet the requirements of EASA Part ARA. GEN.220 is effective in maintaining accurate and up-to-date records related to personnel licences, certificates and ratings.

Safety Recommendation 2020-006

It is recommended that the Federal Aviation Administration require piston engine aircraft which may have a risk of carbon monoxide poisoning to have a CO detector with an active warning to alert pilots to the presence of elevated levels of carbon monoxide.

Safety Recommendation 2020-007

It is recommended that the European Union Aviation Safety Agency require piston engine aircraft which may have a risk of carbon monoxide poisoning to have a CO detector with an active warning to alert pilots to the presence of elevated levels of carbon monoxide.

Safety Recommendation 2020-008

It is recommended that the Civil Aviation Authority require piston engine aircraft which may have a risk of carbon monoxide poisoning to have a CO detector with an active warning to alert pilots to the presence of elevated levels of carbon monoxide.

Safety Recommendation 2020-009

It is recommended that Piper Aircraft Inc. ensure that the 100-hour / Annual maintenance schedule for the PA-46 variants references the engine manufacturer’s guidance, where available, on inspecting and testing the exhaust system.

4.2 Safety Action

Following this accident, the following safety action was taken:

Safety action taken by the CAA

The CAA developed a campaign to raise awareness of unlicensed charters, including publishing a Leaflet, *Legal to Fly,* to inform passengers about flying safely in light aircraft and business jets.

Safety action taken by the engine manufacturer

The engine manufacturer stated that it would:

1. Work with Original Equipment Manufacturers to determine the best way to convey the importance of thorough exhaust system inspections.

2. Review its maintenance and overhaul manuals to determine whether additional elaboration would increase the chance of a qualified mechanic finding a potentially unairworthy condition. It undertook to complete this review in order to have any amplifications implemented in the next FAA approved version of its Standard Practice Manual (M-0).

Appendix A

Scheduled maintenance and fault history

Maintenance organisations

Work undertaken on N264DB during the three years before the accident was carried out predominately by three maintenance organisations, which will be referred to as organisation A, B, and C.

Scheduled maintenance

Annual / 100-hour maintenance, 30 November 2018 (Organisation A)

The documentation[1] for the last Annual / 100-hour maintenance recorded the scheduled inspection as having been carried out at 6,636.2 airframe hours, which was approximately 11 flying hours prior to the accident flight. The undercarriage circuit breaker was replaced during this maintenance activity.

The Certificate of Release to Service signed by the FAA IA had a statement that '*the Altimeter and Transponder were due 24/07/17*'. FAA regulations[2] only permit aircraft to fly in controlled airspace under IFR providing each altimeter and automatic pressure altitude reporting system has been tested and inspected within the previous 24 months.

Annual / 100-hour maintenance,15 December 2017 (Organisation B)

The previous Annual / 100-hr maintenance was completed on 15 December 2017, at 6,583.4 airframe hours. During the inspection the shroud around the right tail pipe was removed in order to inspect the tail pipe heater muff. The maintenance organisation stated that it normally carried out a pressure test of the heater muff but had no record of having done so on this occasion. However, had the inspection revealed any evidence of possible damage or deterioration then a pressure test would have been carried out.

In addition to the scheduled maintenance called up in the Annual / 100-hr schedule, the following work was carried out:

- Replacement of both turbochargers, which would have entailed the removal of the tailpipe / heater muff.
- Replacement of several exhaust system parts.
- Testing of the pitot static system.
- Removal and refitment of the numbers 2 and 5 cylinders following overhaul.

1 Piper aircraft PA-46-310P / 350P Maintenance Manual 5-20-00.
2 Federal Aviation Regulation (FAR) Section 91.215 (a) and 91.411.

- Turbine Inlet Temperature probe replaced and system tested.
- Brake callipers cleaned and tested.
- Ailerons re-rigged.
- Flap actuators removed and inspected. Several flap bell cranks removed for rework. Flaps re-rigged.
- Nose landing gear trunnion replaced.

Recent fault history

There were no recent faults recorded in the aircraft or engine logbook, but the following faults were identified from worksheets completed outside of the Annual maintenance:

21 October 2018 (Organisation A)

The following rectification work was carried out by the maintenance organisation which completed the Annual maintenance in 2018:

- '*Circuit breaker trips on undercarriage selection. Undercarriage hydraulic powerpack replaced and retraction tests carried out satisfactory* [sic]'. The work was certified by an FAA IA and A&P[3] inspector.
- '*Exhaust system TIT probe unserviceable. The probe was replaced, and a system ground run was carried out satisfactory* [sic]'. The work was certified by an FAA A&P inspector.

28 July 2017 (Organisation B)

The work below was carried out by the maintenance organisation that carried out the Annual maintenance in 2016 and 2017. The work order was signed by an FAA IA.

- *'Work to be carried out: Carry out a full hydraulic system test'*.
  - *'Aircraft placed on jacks, landing gear and flap hydraulic system tests carried out i.a.w PMM 27-50-00, 29-10-00 & 32-30-00 all found satisfactory for continued service.*'

3 A&P: airframe and propulsion.

Appendix A (cont)

12 July 2017 (Organisation C)

In early July 2017, the aircraft was taken to Organisation C, which had not previously carried out an Annual maintenance on this aircraft, for an assessment of possible faults on the autopilot, undercarriage and flap system. An FAA IA recorded the following tasks and rectification in the FAA worksheets:

- '*Jack aircraft.*
  - *Aircraft jacked*.
- *Check Hydraulic System pump.*
  - *Inspection of hyd* [hydraulic] *pack showed very low fluid level, pump removed, found pump drive shaft oil seal worn allowing oil into the motor, motor cleaned, hyd level set to full, system placarded inop* [inoperative] *until seal/motor changed work carried out iaw AMM Sect 29-10-0.*
- *Operation of flap system caused hyd over pressure to 2050 psig, excessive play in flap linkage.*
  - *Flap system placarded inop aircraft released for (1) one ferry flight to its maintenance base at Coventry Airport*.
- *Undercarriage system operating satisfactory* [sic].
  - *'Check of u/c* [undercarriage] *system iaw Sect 32-3-000 was satisfactory however excessive wear in all u/c. Placarded inop, until wear rectified, aircraft released for (1) one flight only to a Maintenance Base at Coventry airport*.
- *Check A/P* [autopilot].
  - *'A/P System tested found F/D* [flight director] *not working correctly Tripping A/P out. A/P placarded inop, FD placarded inop.'*

The completed work sheets were retained by Organisation C. No entry was made in the aircraft logbook regarding the unserviceable systems and no Certificate of Release to Service was issued. The FAA IA who made the entries in the worksheets stated that he verbally briefed the condition of the aircraft to the individual who managed the aircraft and tasked him with the work.

Organisation C also sent an e-mail to the individual who managed the aircraft explaining what had been found, saying that there were two airworthiness issues on the aircraft concerning the operation of the landing gear and flaps. Arrangements were then made for the aircraft to be flown with the undercarriage down and the flaps inoperative to another airfield for the faults to be repaired. However, as nothing was recorded in the logbook, Organisation B, which subsequently investigated these faults, said they were unaware of these findings.

For the aircraft to undertake a ferry flight, it required a Special Ferry Permit issued by the FAA International Flight Standards Office Designated Airworthiness Represented (DAR-T) who is based in the USA. No Special Ferry Permit had been requested or issued.

17 February to 19 August 2016 (Organisation B, Independent avionic technician)

Between 17 February and 19 August 2016 an avionic technician, who held an EASA Part 66[4] licence, investigated an intermittent fault on the autopilot and flight director system. During this period, the autopilot was removed and sent to the USA for testing, but no fault was identified. The autopilot and a replacement flight director were fitted to the aircraft and the intermittent fault remained the same. It was subsequently established that manipulation of the connector at the rear of the autopilot computer caused the system to work satisfactorily. A later model autopilot computer was tested on the aircraft and despite manipulation of the rear connector the fault did not reappear. The mechanic advised the individual who managed the aircraft of the finding and recommended that the autopilot computer should be replaced with a later model. However, it was decided to refit the original unit and placard it as INOP. A placard is a label that is attached either on the equipment or on the instrument panel next to the instrument or equipment to alert the pilot to any limitations.

On 27 July 2017, the avionic mechanic received a phone call from Organisation C which was investigating an intermittent fault on the autopilot system. The mechanic informed Organisation C of his findings and recommendation to replace the autopilot computer.

The investigation into the accident involving N264DB could find no documentation or evidence that the computer had been replaced or the intermittent fault rectified.

4 The technician's Part 66 (B1 & B2) licence allowed him to certify avionic work on EASA regulated aircraft. He did not hold any FAA licences, and any work he carried out on N264DB would have to have been certified by the FAA IA at Organisation B.

Appendix A (cont)

7 January 2016 (Organisation A)

An FAA IA inspector recorded the following work in a worksheet and signed a Certificate of Release to service.

- ‘Investigate poor performance from port brake.
  - Brakes on port pedal failed. [Redacted] requested work to restore left foot motor. Drive to Gamston and back bleed brakes. Peddle restored. After third flight failed again. Trip back to Gamston. P1 & P2 foot motors removed, cleaned, resealed and refitted. Braking system bled of air. Brakes operated. P1 & P2 brakes now satisfactory.’

Appendix B

Search for, and survey of the aircraft wreckage

Search and rescue

On 21 January 2019, at 2024 hrs, Jersey Air Traffic Control informed Guernsey Coastguard that they had lost radio and radar contact with a light aircraft, callsign N264DB, with two persons on board, flying at 2,000 feet approximately 15 nm north of Guernsey.

A search operation commenced at 2055 hrs on 21 January 2019 and included: the lifeboats from Guernsey and Alderney; Channel Islands Air Search aircraft; three coastguard helicopters; a fixed wing aircraft from the UK; helicopters and fixed wing aircraft from France; a privately-owned helicopter based in Brechou Island; a number of fishing and merchant vessels; and searchers on foot.

The search was coordinated by Guernsey Coastguard, assisted by: Alderney Coastguard; Jersey Coastguard; HM (UK) Coastguard; and CROSS Jobourg (France) and Guernsey air traffic control. A cumulative area of 1,800 square miles was searched but no wreckage or survivors were found.

The Guernsey Coastguard made an announcement that the search had been suspended at 1515 hrs on 24 January 2019; broadcasts to shipping to look out for the wreckage continued for a further 48 hours.

Surface wreckage

In the week following the accident, members of the public found two seat cushions near Surtainville, an arm rest at Tréauville and a section of fuselage skin at Sainte-Maire de la Mer along the coast of the Cotentin Peninsula, France. A seat cushion also washed up in Bonne Nuit Bay on the North Coast of Jersey (Figure B-1).

Recovery of passenger seat by fishing boat

On 26 September 2019, the crew of a trawler informed the French authorities that they had brought up what they believed to be an aircraft seat while conducting a trawl approximately 7 km to the west of the location of the main wreckage site. The seat was assessed by the AAIB as the left middle passenger seat from N264DB (Figure B-2).

Appendix B (cont)

Figure B-1

Location of aircraft wreckage washed-up on shore

Figure B-2

Passenger seat from N264DB

AAIB activity to locate and survey the wreckage

Following an aircraft accident at sea, an underwater search operation may be undertaken by the Safety Investigation Authority (SIA) leading an investigation to locate and gather evidence which may establish the cause of the accident. The decision to conduct an underwater search is determined on a case-by-case basis, and a search is only carried out if it is considered safe and practical to do so. The aim of a search is to determine the location of the wreckage and to undertake an underwater survey; wreckage is only recovered if it is considered safe, feasible and necessary in order to understand the cause of the accident.

Probable location of the wreckage on the seabed

On the morning of 22 January 2019, while the search and rescue operation was ongoing, the AAIB started to collect and analyse radar data to establish the probable location of the aircraft wreckage. At the same time, the Ministry of Defence's Salvage and Marine Operations (SALMO) Project Team started working with the AAIB to determine options for locating the wreckage and the feasibility of conducting an underwater survey. The AAIB established the most likely location for where the aircraft struck the surface of the sea by analysing radar data and the flight profile during the final minutes of the flight. SALMO then factored in the depth of water and tidal flow to determine the primary area for the seabed search, which was an area of 4 nm^2 approximately 22 nm north-north-west of Guernsey.

Coordination of the seabed search

Through SALMO, the AAIB contracted a specialist survey vessel, the Geo Ocean III, to undertake an underwater survey of the seabed to try to locate and identify wreckage from the aircraft. The ship was not equipped to recover the aircraft. Close liaison was established with a privately funded search, conducted on behalf of the passenger's family by Blue Water Recoveries, to maximise the probability of locating any wreckage and to ensure a safe search operation. On 30 January 2019, the AAIB held a meeting with SALMO and a representative of Blue Water Recoveries to agree a strategy and protocols for the search.

The search was planned to be conducted in two phases. The first phase would be a survey of the seabed using towed side-scan sonar to identify objects of interest. This phase would be carried out by two vessels: the Geo Ocean III, contracted on behalf of the AAIB, and FPV Morven, contracted on behalf of the passenger's family. The second phase would be an examination of those objects when the tidal flow allowed, using the camera on a Remotely Operated Vehicle (ROV) deployed from the Geo Ocean III (Figure B-3).

Appendix B (cont)

Figure B-3

ROV on Geo Ocean III

To ensure safe separation between the vessels and towed sensors during the first phase, and to maximise the efficiency of the search, the area was split into two parts and each vessel was allocated one part (Figure B-4). The prime area of interest would be searched by both vessels.

Appendix B (cont)

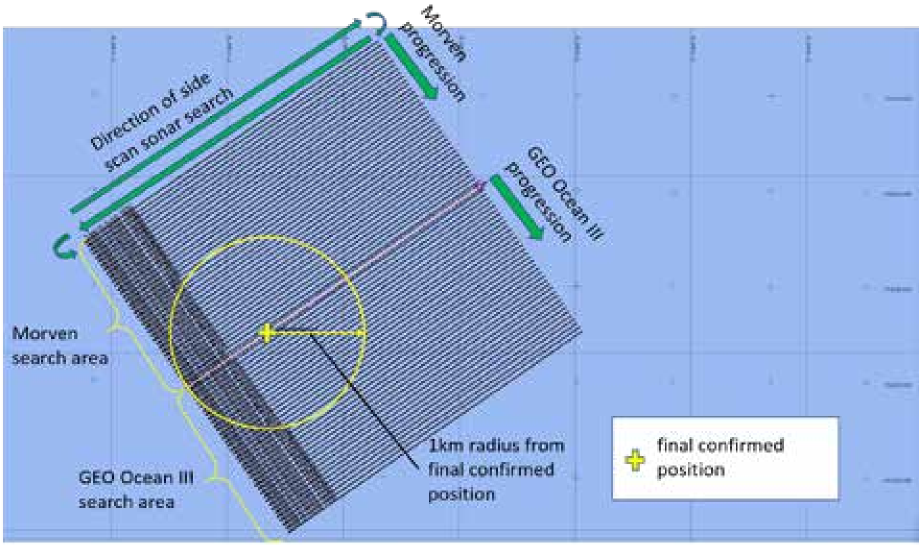

Figure B-4

Seabed search strategy

Both vessels began their side-scan survey of the seabed on the morning of 3 February 2019. Early in the search, the FPV Morven identified an object of interest at a depth of approximately 68 m and cleared the immediate area. The Geo Ocean III subsequently used its own side-scan sonar to observe the object (Figure B-5).

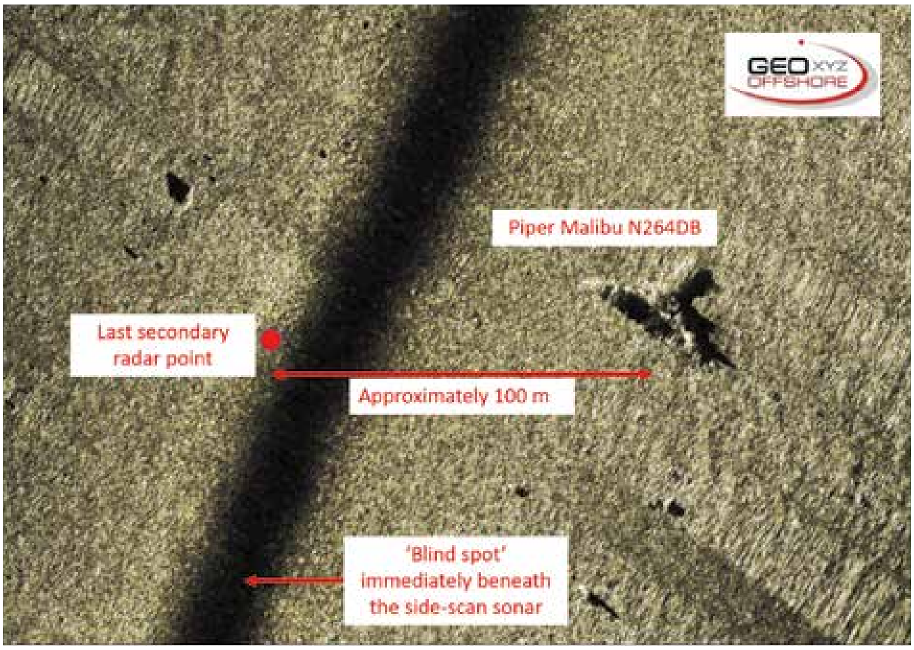

Figure B-5

Side-scan sonar image of N264DB

Appendix B (cont)

Identification and survey of the wreckage

The Geo Ocean III began a search of the seabed near the object of interest using its ROV, which was equipped with a video camera, and the object was identified as the wreckage of N264DB (Figure B-6).

Figure B-6

Tail section of N264DB on seabed at a depth of 68 m

The fast tidal flow limited the period that the ROV from Geo Ocean III could operate between tides in the area of the wreckage. Despite this restriction, the ROV undertook ten dives between 3 and 6 February 2019 before the weather deteriorated and the ship had to return to shore. During the dives a full video survey of the wreckage and surrounding area was carried out. The body of the passenger was found held in place by the wreckage and recovered to the ship, but there were no signs of the pilot in the wreckage or surrounding area.

Subsequent video survey by Blue Water Recoveries

On 27 February 2019, Blue Water Recoveries, acting on behalf of the pilot's family, arranged for divers to search the wreckage to look for signs of the pilot, but he was not found.

The AAIB provided the divers with a briefing on the investigation's areas of interest in the wreckage, and they carried out a focused video survey using small handheld cameras. Three video recordings, lasting 21 minutes, were subsequently provided to the AAIB to assist with the assessment of the damage to the aircraft. Figure B-7 shows an image from one of the video recordings, showing the heater muff and turbocharger.

Figure B-7

Right tailpipe and heater muff / shroud
(image taken from video provided by Blue Water Recoveries)

Assessment of the wreckage

The videos enabled an assessment of the wreckage to be undertaken to help determine the accident sequence and eliminate possible causes. They also enabled an assessment to be made of the potential benefits to the investigation in recovering the wreckage. Given the depth of water, strong tidal currents and poor sea conditions, it was considered that the benefits to the investigation in recovering the wreckage over the winter months were outweighed by the risks and cost involved. The wreckage was also expected to deteriorate during that period as a result of being in salt water and subject to fast tidal currents.

The feasibility and potential benefit of recovering the wreckage was reviewed periodically during the investigation, with a major review taking place after the high level of COHb in the passenger's blood was identified by the toxicology report. However, it was concluded that the poor condition of the wreckage meant its recovery was unlikely to add significantly to the investigation, and therefore the cost and risk involved were not justified. The relevant safety issue of CO entering the cabin had been identified and could be addressed with the evidence already collected.

Images from the video recordings taken by the ROV from Geo Ocean III are shown in Figures B-8 to B-12.

Appendix B (cont)

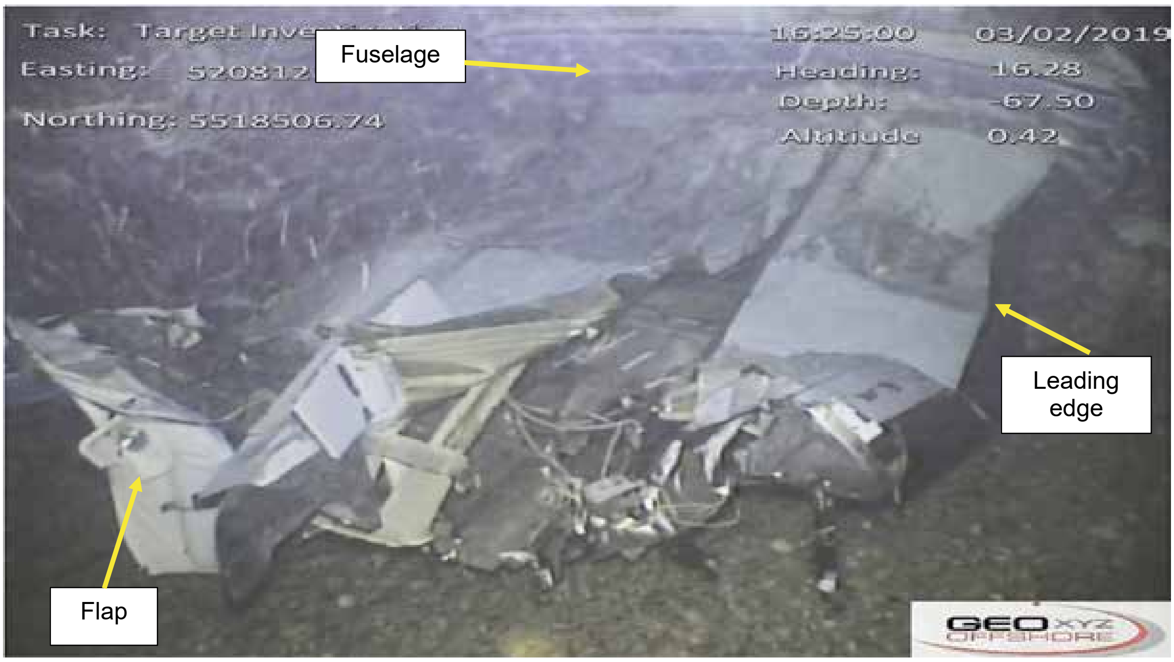

Figure B-8

Remains of right wing

Figure B-9

Forward of cockpit

Appendix B (cont)

Figure B-10

Disruption to cockpit and engine

Figure B-11

Damage and disruption to instruments and controls

Appendix B (cont)

Figure B-12

Missing fin and horizontal stabiliser

Correction:

In April 2021, it was noted that Figure B-4, Appendix B, showed an error in the planned progression of the search vessels. This Figure has now been updated and the correct version is shown in this report.

Full details of the correction can be found on the AAIB Website on the N264DB report page: (https://www.gov.uk/aaib-reports/aircraft-accident-report-aar-1-2020-piper-pa-46-310p-malibu-n264db-21-january-2019)

The online version of the report was corrected on 26 April 2021.

Appendix C

CAA Campaign on Unlicensed Charters

Appendix C (cont)

If you are a paying passenger in an aircraft other than a scheduled airliner, how can you be sure your flight is legal and safe?

Whether you are flying as a passenger on business or leisure, if you or your employer has paid for a flight in a light aircraft or business jet then that flight must meet certain safety standards. Such a fl often called an air taxi or an air charter, is recognised in law as commercial air transport and should never be considered as a private arrangement. The organisation or individual operating the flight must have the correct certifi insurance and licences. If you pay for a fl which is unlicensed there could be serious consequences for your safety and you may not be insured. If you knowingly use an illegal operator you may also be breaking the law and could be prosecuted.

Make sure your flight is protected. Unscrupulous aircraft operators do exist. These people are only too willing to exploit the good faith of paying passengers for a quick profit. Help us stamp out this illegal and dangerous activity by only using approved operators.

You should do your own research by finding out the name of the organisation actually providing the flight (the operator). The company who sold you the flight (the ticket seller) may be a different entity. By law you must be told the name of the operator. You can then check if they are legal by visiting caa.co.uk/aocholders. You should also ask for the name and qualifications of the pilot.

If you cannot find out the company name, contact us at fod.admin@caa.co.uk and we will look into it for you.

Any company, organisation or individual that operates public transport flights must have permission from the Civil Aviation Authority. They will need to hold an Air Operator's Certificate (AOC) to prove they meet all relevant insurance and safety requirements. Such operators will be regularly inspected and audited by the CAA, and the pilot will need to have a commercial licence.

If a flight has been arranged for you, and you are not sure about the status of that flight, do not assume it is legal. Do your own research and find out if the operator has an AOC. If you are told the operator does not need an AOC, ask why not.

If you think you are being offered an illegal flight report it to the CAA iet@caa.co.uk. We will prosecute illegal operators.

Appendix D

Extract from Continental Aircraft Engine Maintenance Manual:

Standard Practice for Spark Ignited Engines

The following extract is taken from the Continental Aircraft Engine Standard Practice Maintenance Manual (Publication M-0), which was first issued on 15 April 2016, to bring together in one document a number of standard practices. This Manual is applicable to the TSIO-520-BE engine fitted to N264DB. The introduction to the manual states:

> *'This manual incorporates maintenance and service information contained in Continental Motors Service Documents common to the horizontally opposed, spark ignition, AvGas aircraft engines conforming to Type Certificate held by Continental Motors. This document is supplemental to the Instructions for Continued Airworthiness provided in the manuals listed in Section 1-1.1. Instructions contained in the Service Documents listed in Section 1-2.4 are superseded by instructions in this manual upon release, except for those Mandatory Service Bulletins (MSBs) and Critical Service Bulletins (CSBs).'*

The extract is as follows:

Engine Inspection and Service

6-4.21. Turbocharger and Exhaust System Inspection

Purpose

Verify the integrity of the turbocharger and exhaust system, including the heater muff (if installed). Isolate and correct cracks or leaks in the exhaust system.

Frequency

During 100-hour/Annual inspection

> *CAUTION: Ensure the turbocharger and exhaust system components are cool before inspection to prevent burns.*

Procedure

1. *Remove airframe items that hinder visual inspection of the exhaust and turbochargers.*

Appendices

Appendix D (cont)

2. *Clean the exhaust system, removing oil and grease, by spraying the exhaust systems parts with Stoddard solvent. Allow the solvent to drain and wipe the parts with a clean cloth.*

   CAUTION: Cracks in the exhaust system can release carbon monoxide in the nacelle or the cabin; correct exhaust leaks before further flight.

3. *Inspect the exhaust system components according to the instructions in Table 6-24.*

Part	***Inspection Action***
Stacks *Risers* *Elbows*	*Check parts for the following:* *Burned areas* *Cracks* *Loose parts/hardware* *Pay particular attention to welded areas and seams, checking for cracks.* *Replace parts that are cracked, burned, or worn*
Slip joints	*Check for bulges, cracks, or hot spots (see Figure 6-96)*
Multi-segment V-band clamps	*Inspect spot-weld (or rivet) areas for cracks or physical damage.* *Inspect the corner radii of clamp inner segments for cracks with a flashlight and mirror. Inspect the inner segment spacing.* *Inspect the clamp outer band for flatness using a straight edge, especially within 2 inches of spot-weld tabs that retain the T-bolt fastener - clearance must be less than 0.062 inches.* *Verify 100% inner and outer band segment contact.* *To replace a multi-segment V-band clamp, refer to the primary ICA. Ref: Section 1-1.1*
Heater muff	*Inspect the heat exchanger seams, joints and transitions with a flashlight and mirror or a flexible borescope for physical damage, cracks, corrosion, and burn-through. Inspect connecting flanges for security and proper mating.*

Table 6-24
Exhaust Inspection Criteria

4. *Connect a high volume, dust-free, air pressure source to the exhaust tailpipe outlet.*

5. *Apply five (5) psi of air pressure to the exhaust system. Apply soapy water to the exhaust system and check for bubbling in areas of the exhaust other than the slip joints. If bubbling is found, replace the leaking exhaust components according to the instructions in primary ICA (Ref: Section 1-1.1) or aircraft maintenance manual.*

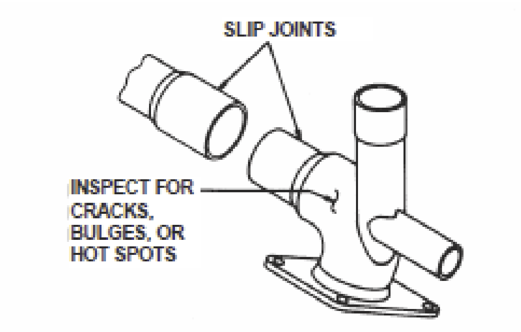

Figure 6-96. Exhaust Slip joint Inspection

WARNING

Exhaust system weld repairs may only be performed by an FAA Part 145 authorized repair station certified to perform the specific repairs.

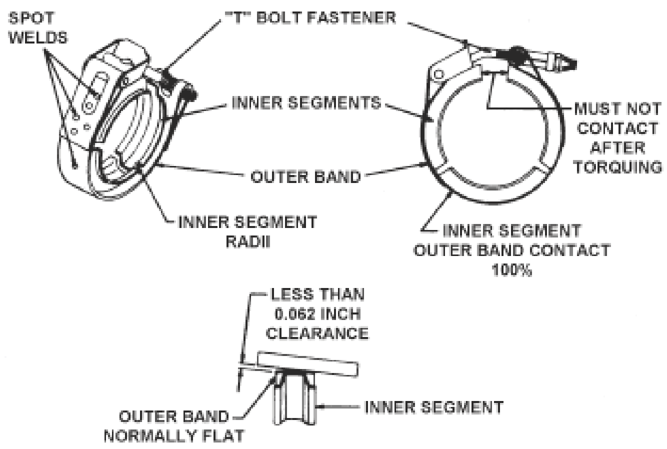

Figure 6-97. V-band Clamp Inspection

6. *Visually inspect the exhaust stacks and transition unit for wear, leaks, cracks, or distortion. Replace worn, leaking, cracked, or distorted exhaust parts. Inspect the exhaust manifold connections at the cylinder to verify the physical security of*

the exhaust flange, gasket and exhaust manifold fasteners. Exhaust system removal and installation procedures may be found in the primary ICA (Ref: Section 1-1.1) or the aircraft maintenance manual, if disassembly is required.

7. *Remove the multi-segment V-band clamps from the exhaust tailpipes according to instructions in the primary ICA (Ref: Section 1-1.1) or the aircraft maintenance manual. Clean the outer band of the multi-segment V-band clamps with crocus cloth. Inspect the V-band clamps according to the instructions in Table 6-24.*

8. *Inspect the turbocharger oil reservoirs, oil inlet and outlet fittings and surrounding area for signs of leakage. Torque fasteners or fittings to Appendix B specifications or replace leaking parts, as required to remedy leaking reservoirs or fittings.*

9. *Remove the induction air supply from the turbocharger compressor according to the aircraft manufacturer's instructions. Inspect the induction air supply duct for wear, deformation, cracks or other physical damage; replace, if necessary.*

10. *Remove the turbocharger compressor discharge duct from the induction system according to instructions in the primary ICA (Ref: Section 1-1.1) or the aircraft maintenance manual. Inspect the hardware for wear, deformation, cracks or other physical damage; replace, if necessary.*

11. *Inspect the turbine and compressor housings for cracks or physical damage, especially at the mounting flanges. If cracks or physical damage is discovered, replace the turbocharger with a new, rebuilt or serviceable unit.*

12. *Inspect the turbine and compressor wheel blades for damage. If turbine or compressor blades are damaged, replace the turbocharger with a new, rebuilt or serviceable unit.*

13. *Spin the turbine shaft to check for freedom of movement and end play. If the turbine or compressor blades touch the housing during rotation, if the shaft does not rotate freely, or if the shaft exhibits noticeable "wobble" during rotation, replace the turbocharger with a new, rebuilt or serviceable unit.*

14. *Inspect the interior of the turbine and compressor housings for oil, indicating oil seal damage or a faulty check valve. If oil is found inside the housing, troubleshoot to isolate cause of oil accumulation.*

15. *Inspect the wastegate for cracks or physical damage. If the wastegate is cracked or damaged, replace the wastegate with a new, rebuilt or serviceable unit. Inspect the security of the mounting flange fasteners, retorque if fasteners appear loose.*

16. *Inspect the wastegate actuator fittings for leaks and physical security; retorque loose fittings to Appendix B specifications. If leaks persist, replace O-rings, retorque fittings and repeat leak inspection after a ground engine run. Inspect the wastegate actuator hydraulic hoses for chafing, nicks, cuts or leaks; replace hoses exhibiting these conditions.*

17. *Inspect the wastegate actuator and butterfly valve for general condition and freedom of movement. Check the link rod pins and levers for wear. If the wastegate actuator, butterfly valve, link rod pins or levers are worn, binding, or damaged, replace the wastegate actuator.*

18. *Clean and lubricate the butterfly valve and associated linkages.*

19. *For applicable engine models: remove, disassemble, and inspect the turbocharger oil supply check valve according to the instructions in Section 6-4.21.1.*

20. *Inspect the wastegate controller and fittings for physical condition and security. If the wastegate controller exhibits physical damage, replace the wastegate controller with a new, rebuilt, or serviceable unit. Inspect the wastegate controller hoses, or tubes, for chafing, nicks, cuts or leaks; replace hoses exhibiting these conditions. Inspect the wastegate controller reference hoses or tubes for bends, dents, nicks or leaks; replace reference lines exhibiting these conditions.*

21. *Inspect the wastegate controller (Figure 6-56) housing for oil leaks around the diaphragm, check pressure sensing*

port, oil inlet, oil outlet, or adjustment screw. If oil is leaking from a fitting, remove the fitting and replace O-rings, install and torque the fitting to Appendix B specifications. If oil is leaking from the housing, replace the wastegate controller with a new, rebuilt, or serviceable unit.

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Unless otherwise indicated, recommendations in this report are addressed to the appropriate regulatory authorities having responsibility for the matters with which the recommendation is concerned. It is for those authorities to decide what action is taken. In the United Kingdom the responsible authority is the Civil Aviation Authority, Westferry Circus, Canary Wharf, London, E14 4HD or the European Union Aviation Safety Agency, Postfach 10 12 53, D-50452 Koeln, Germany.

Aircraft Accident Report 1/2020

Report on the accident to
Piper PA-46-310P Malibu, N264DB
22 nm north-north-west of Guernsey
on 21 January 2019