ACCIDENT

Aircraft Type and Registration:	Boeing A75N1(PT17) Stearman, N707TJ
No & Type of Engines:	1 Pratt &Whitney R-985 engine
Year of Manufacture:	1940 (Serial no: 75-950)
Date & Time (UTC):	4 September 2021 at 1448 hrs
Location:	In the sea off Sandbanks, Poole, Dorset
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	4,494 hours (of which 3,581 were on type) Last 90 days - 175 hours Last 28 days - 62 hours
Information Source:	AAIB Field Investigation

Synopsis

While performing an aerobatic wing walking display over the sea at Bournemouth Air Festival, the aircraft experienced a reduction in engine power. The pilot stopped the display routine and flew the aircraft west, along the coast, with the intention of returning to Bournemouth Airport. The wing walker returned to her seat in the front cockpit. Although the aircraft was initially able to maintain height, the engine subsequently experienced a complete loss of power and the pilot ditched in the entrance to Poole Harbour. The aircraft flipped over on contact with the water, but both occupants were able to exit the aircraft unaided.

The investigation determined that during the display the engine suffered a loss of engine power due to failure of the oil inlet pipe, most likely due to fatigue, which prevented oil being supplied to the engine. This was precipitated by a fatigue failure of the metal strap which supported the weight of the oil inlet pipe. The fatigue failure initiated at an area of mechanical damage on the surface of the support strap, which had been caused by over-tightening of the retaining nut.

History of the flight

The aircraft was part of a two aircraft display team performing at the Bournemouth Air Festival from 2 to 5 September 2021. The team consisted of four people, with one pilot and one wing walker in each aircraft. Following the flight on 3 September 2021, the pilot of N707TJ refuelled the aircraft and confirmed that the oil level was between 7 and 8 USG.

On the day of the accident the team met to discuss the planned display routine. This included a walk-through of the display sequence and discussion of actions to take in the event of various types of emergencies. The discussion included the technique required for ditching the aircraft and the actions for egress in the event of a ditching.

Prior to starting the engine, the pilot turned the propeller by hand to ensure there was no oil pooled in the lower cylinders. He reported that he did not see any sign of oil on the ground. He started and warmed-up the engine in accordance with the operator's checklist and completed the power checks, which were satisfactory.

The two aircraft took off from Bournemouth Airport at 1437 hrs with the wing walkers already on the wing and with N707TJ as the lead aircraft. They changed to the display radio frequency and when at 'Town Hold'[1] were cleared by the Flight Display Director (FDD) to proceed directly to the display area to begin their display. The pilot subsequently reported to the AAIB that the oil temperature and pressure were normal, and the engine was responding as expected. The key locations during the flight are shown in Figure 1.

Figure 1

Display area and key locations

(©Google Earth, map data SIO, NOAA, US Navy, NGA, GEBCO)

Footnote

1 Town Hold was a holding point used to manage the aircraft flow to and from the display area situated to the east of the airport.

The team commenced the display at 1443 hrs and completed the first two manoeuvres during which the pilot reported that the engine rpm was approximately 2,000 rpm and the manifold pressure 32 inches. Positioning for the next manoeuvre, both aircraft flew away from the crowd line and, after increasing power, the pilot noticed that the aircraft was not climbing, and the rpm was lower than expected at around 1,800 rpm. The pilot checked and confirmed that the throttle lever was fully forward. He also checked the fuel, magnetos, and carburettor icing controls, which were all in the correct positions, and the engine temperature and pressure indicators which were normal.

As the engine was not delivering full power, the pilot turned to depart the display area to the west. He rocked the wings, which was the agreed signal to attract the attention of the wing walker and indicated by hand signal for her to dismount the wing. The wing walker dismounted, strapped into the front cockpit, and disconnected the wing walking safety restraint.

The pilot reported on the display frequency that he had an engine problem and advised that he planned to return to Bournemouth Airport. The pilot of the other aircraft followed N707TJ at a distance and instructed his wing walker to dismount. As N707TJ began to route west along the coast, at about 600 ft above mean seal level (amsl), the engine misfired. The pilot changed frequency to Bournemouth Tower, declared a PAN and was cleared to route direct for any runway.

While there was insufficient power available to climb, the aircraft was still able to maintain height. However, not wishing to cross a built-up area at 600 ft amsl and mindful that the engine might stop, the pilot continued to fly west parallel with the coast. His intent was to fly around the west of Bournemouth and Poole and return to the airport over the more open ground to the north. He then noticed oil streaming out of the engine cowling and coming past the cockpit.

Recognising that there was no opportunity to land on the beach, owing to the crowds and the available distance between the wooden groynes[2], the pilot asked Bournemouth Tower for a steer to an open field and was given a heading to Parkstone golf course. However, the pilot considered that the golf course would be occupied, and a safe emergency landing could not be assured. As he was now approaching the Sandbanks area, and losing height, he set the aircraft attitude to achieve the best glide speed of 70 mph and aimed for some open fields on the Studland side of Poole Harbour. Around this time, the engine produced a loud mechanical noise, vibrated violently, and suffered a significant loss of power.

The entrance to Poole Harbour was ahead and the pilot identified an area clear of boats in which to ditch, located between the breakwater and the shoreline, and separated from the channel by a line of poles. He reported that the water was 'choppy' and the wind was light from the west. The last speed he observed was 70 mph (stall speed was 55 mph) and that he pulled back on the control column to put the tail into the water first. Video recordings showed the aircraft in a stable descent, with the propeller turning, and it adopted a slightly

Footnote

2 A groyne is a barrier built out into the sea from a beach to stop erosion.

nose-high attitude as it neared the water (Figure 2). On contact with the water the aircraft rapidly flipped over onto its back and came to rest close to the chain ferry slipway on the Sandbanks side of the harbour entrance; the ferry was on the other side of the harbour. The pilot and wing walker exited their cockpits, which were submerged, and were picked up by a small leisure craft.

Figure 2

Stills taken from video just prior to ditching (Used with permission)

The time from the initial indications of an engine problem to the ditching was about four minutes. The ditching occurred 3 nm to the west of the display area.

The pilot of the other aircraft in the formation shadowed N707TJ to the point that it ditched and then orbited for a short time. He declared a MAYDAY to Bournemouth Tower who informed the Distress and Diversion Cell at the National Air Traffic Service Swanwick at 1450 hrs.

Emergency response

The police control room was informed of the accident at 1452 hrs. Although the accident occurred outside of the air display area, a multi-agency control centre (MACC) established for the Air Festival took control of the incident, with the police as the lead agency. The police coordinated the response with other agencies using local and air show resources. The MACC informed a RNLI vessel supporting the festival that the aircraft had a problem, which then followed the aircraft and arrived on scene shortly after the pilot and wing walker had been rescued by a leisure boat and transferred to a working boat operating in the area.

The wing walker, who had knocked her head during the accident, was examined by a paramedic on the RNLI vessel. Both the wing walker and pilot were taken by ambulance to hospital for medical checks and released later that day.

The FDD made the decision to cancel the remainder of the flying display for that day.

Recorded information

Photographs and videos taken during the accident flight on 4 September 2021 show heavy oil staining on the underside of N707TJ's fuselage aft of the engine cowling (Figure 3) and lighter oil staining on the upper fuselage, aft of the rear cockpit. Photographs taken the previous day during and at the end of the display showed no oil staining present.

Figure 3

Oil staining on underside of N707TJ (white aircraft) fuselage during accident flight

The oil staining was evenly distributed across the bottom of the fuselage and emanated rearwards from the bottom of the engine cowling, which eliminated the possibility that the oil came from the oil cooler or the engine exhaust.

The final part of the ditching was captured by CCTV from a nearby hotel which shows the aircraft flipping over very rapidly.

Aircraft information

The Boeing Stearman 75 (Stearman) is a two-seat tandem biplane, with a fixed landing gear and tailwheel configuration. The fuselage is of tubular welded steel construction with a secondary aluminium structure. The wings and centre section have wooden spars covered with aluminium compression struts and steel bracing wires. The fuselage and wings are fabric covered.

The accident aircraft, originally powered by a 220 hp Continental engine, was manufactured in 1940 for the United States Navy and remained in service until 1944. The aircraft subsequently transferred to civilian use and was re-registered several times.

Over the intervening years the aircraft underwent various modifications, embodied under FAA Supplemental Type Certificates, to increase aircraft performance and allow inverted aerobatic flight. The modifications included in 1974 the replacement of the original engine and propeller with a 450 hp radial Pratt & Whitney R-985-AN14B 'Junior Wasp' engine and a constant speed Hamilton Standard 2D30/6101A-12 propeller.

In 1988 the aircraft was rebuilt and re-registered as N707TJ. The rebuild included the installation of an overhauled R-985 engine, modification of the fuel and oil systems to allow inverted flight and various aerobatic modifications. The original oil tank was replaced with a larger tank of 8 USG capacity, and this was relocated from the engine bay to beneath the baggage compartment, with associated modifications to the oil system to re-route the supply and return lines. A wing walking rig on top of the upper wing centre section and an aerobatic display smoke system were also added. N707TJ was imported to the UK in 1990 when it entered service with the current operator.

The R-985 engine installed at the time of the accident was fitted in 2013 following the failure of the previous engine.

Aircraft maintenance

N707TJ was primarily maintained by the operator's engineer. The maintenance was inspected and certified by an external FAA licensed engineer.

The most recent annual inspection was completed on 21 January 2021. During this inspection a cylinder was replaced on the engine, a compression check was carried out and an engine ground run performed. Except for a 20-minute check flight flown in April 2021, the aircraft did not fly again until August 2021. In June 2021, the engine mounts and both carburettors were replaced and an engine ground run was carried out. The aircraft was subsequently flown for a total of 6 hours and 50 minutes, over 10 flights between 3 August 2021 and the accident flight. At the time of the accident, the aircraft had accumulated a total of 14,809 hours and the engine had accrued 475 hours since overhaul.

Accident site

The aircraft ditched in the sea in the entrance to Poole Harbour on the Sandbanks side, and subsequently sank. The AAIB did not attend the accident site and the aircraft was recovered from the water by marine contractors under the direction of the Poole Harbour Master.

Examination of wreckage

Aircraft

Photographs taken during and after the recovery of the aircraft from the water showed that the lower right wing had separated at the spar stub and both upper and lower right wings had collapsed on top of the forward cockpit. The aircraft had suffered substantial damage to the upper surface of the fuselage, consistent with it striking the water in an inverted orientation. The tailplane exhibited damage associated with water impact and the recovery.

The aircraft was examined by the AAIB several days after the accident, after it had been transported by road to the operator's facility. The wings had been removed to facilitate transportation. Both cockpits showed evidence of prolonged immersion in water but were otherwise free from damage and the integrity of the cockpit structure was maintained.

The engine cowlings were missing, but the engine and propeller were largely intact and free from impact damage. Oil residue was present on the fuselage sidewalls, upper and lower surfaces, and on the engine firewall. There was no evidence of oil in the oil tank.

Engine oil inlet pipe

Forward of the engine firewall, the oil inlet pipe comprises a flexible section and a rigid section, which is attached to a mounting boss on the bottom of the engine oil pump via a 90º threaded joint. Incorporated in the rigid section of the pipe is a port for the engine oil temperature probe. A metal strap supports the weight of the rigid section of the oil pipe. The strap is retained at its upper end on a mounting stud for one of the oil drain lines and is secured by a nut.

Visual examination of the engine revealed that the oil inlet pipe was broken at the point where it attached to the engine casing (Figures 4 and 5). The rigid section of pipe had fractured at the mounting boss and the support strap had fractured at a fastener hole. An area of damage was evident on the flexible section of pipe, but this was limited to a tear in the fire-retardant sleeve on the pipe and the inner pipe was intact at this location. This damage may have occurred during recovery of the aircraft from the water, as the engine cowlings which would normally protect this part of the engine bay were no longer present.

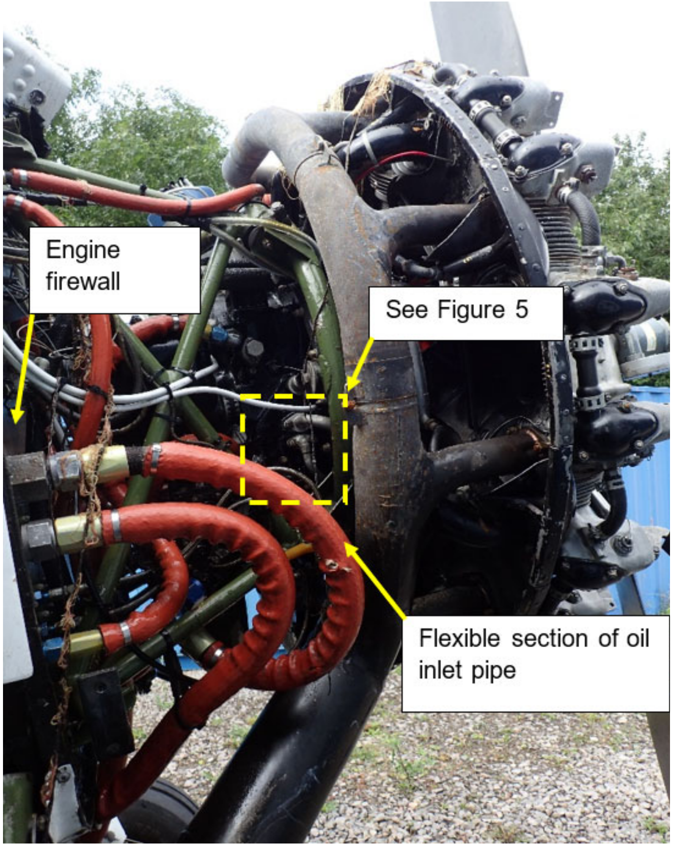

Figure 4

N707TJ's engine viewed from right side showing oil inlet pipe

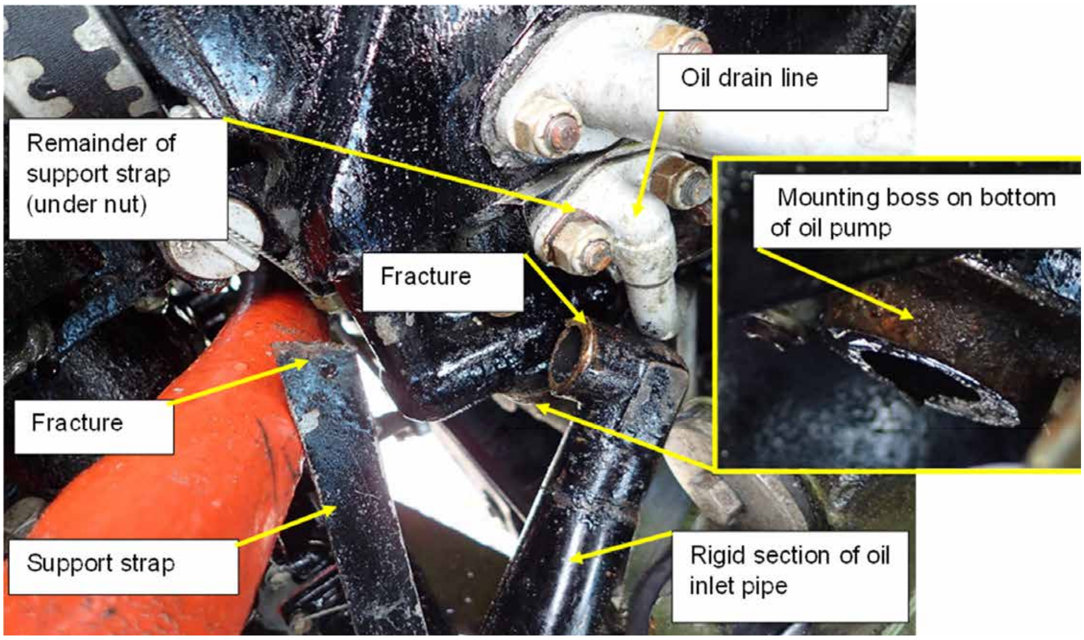

Figure 5

Fractured oil inlet pipe and support strap

Metallurgical examination of the oil inlet pipe and mounting boss

General

The oil inlet pipe, mounting boss and part of the support strap were subjected to a metallurgical examination.

Failure had occurred at a fastener hole in the support strap and on the threaded section of pipe that connected to the mounting boss. Part of the threaded joint remained inside the mounting boss (Figure 6). The support strap and main oil pipe were made from steel. The right-angled threaded end piece of the oil pipe which had fractured was made from a leaded gunmetal casting. It appeared that the gunmetal end fitting had been brazed to the steel pipe.

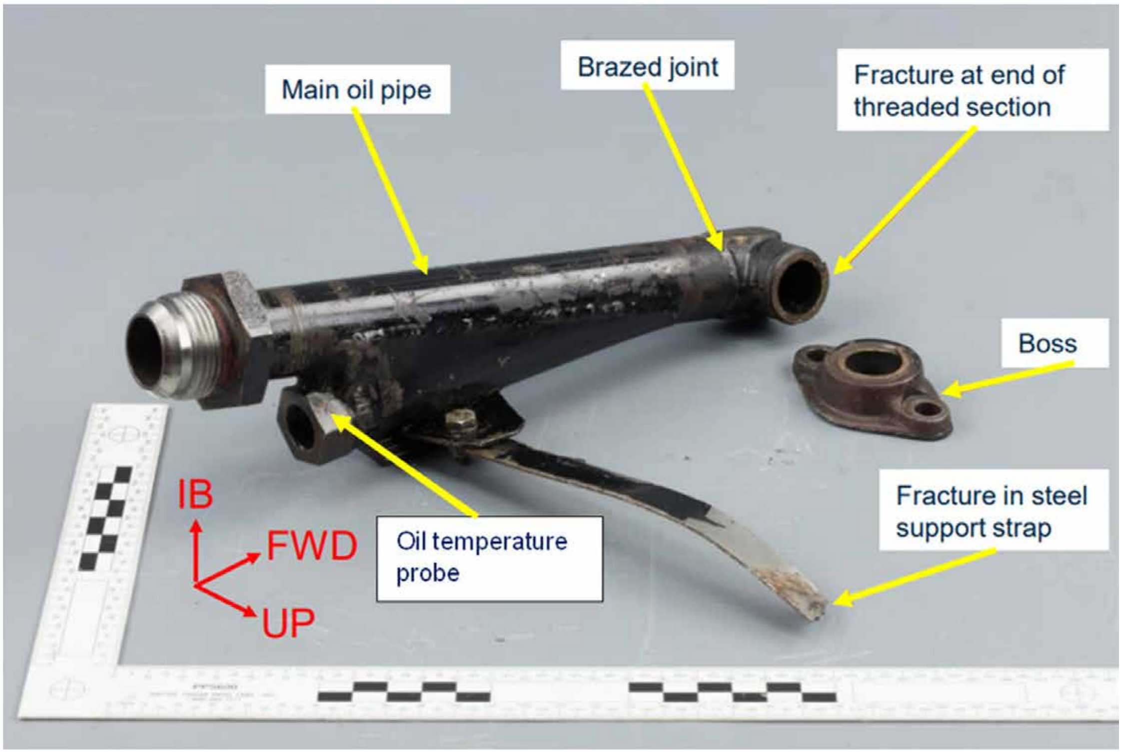

Figure 6

Rigid section of the oil inlet pipe

Support strap

Visual examination of the support strap at the fracture location showed evidence of mechanical damage (witness marks) around the fastener hole on both sides of the strap (Figure 7). The witness marks were circular in shape and consistent with a nut (possibly in combination with a washer) having been over-tightened. No washer was present when the aircraft was examined.

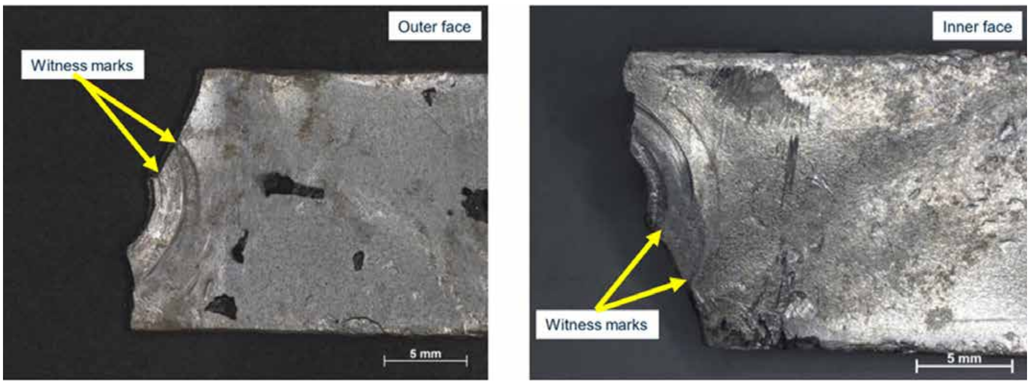

Figure 7

Witness marks around fastener hole on support strap outer face (left image) and inner face (right image)

Scanning electron microscope (SEM) examination of the fracture surface showed extensive corrosion. After cleaning to remove the corrosion, fatigue striations were observed across most of the fracture surface on both sides of the fastener hole. The fatigue initiated within the mechanical damage around the fastener hole on the outer face of the support strap and propagated towards the inner face. A small amount of overload was observed at the right edge of the fastener hole on the inner face. The end of the fatigue crack on the left side of the fastener hole had been destroyed by mechanical damage (Figure 8).

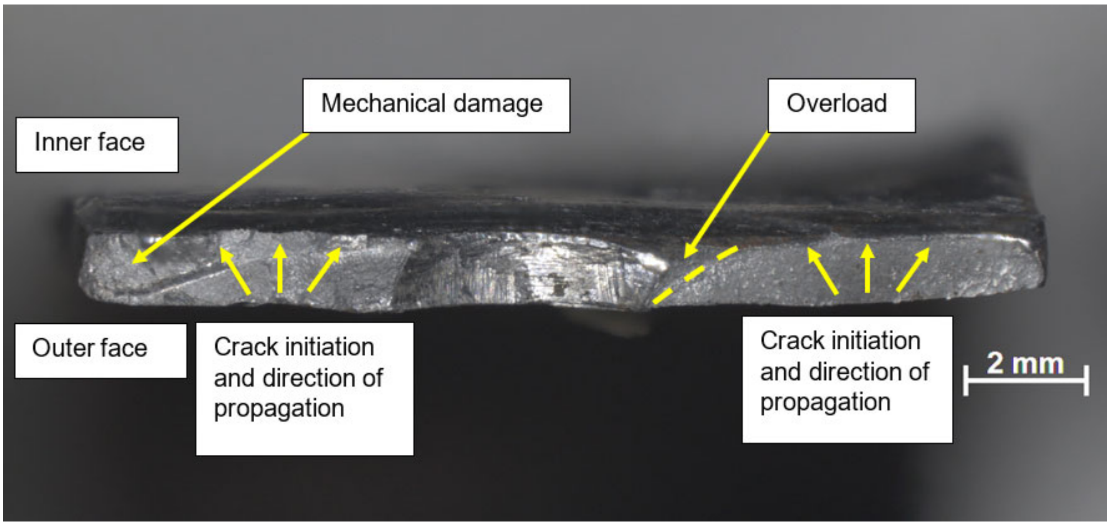

Figure 8

Key failure features identified on the fracture surface of the support strap (Fatigue striations not shown in this image)

Oil pipe threaded joint

The fracture surface of the part of the threaded joint of the oil pipe which remained inside the mounting boss was examined. Visual examination showed that the topography of the fracture surface was typical of overload failure, with no areas that appeared to be consistent with progressive crack growth. The fracture in the oil pipe occurred in the root of a thread.

A step was evident in the fracture surface at the 12 o'clock position (Figure 9). In threaded components, this usually occurs at the last part to fracture. This suggests that crack initiation is likely to have occurred opposite to this (around the 6 o'clock position), with the crack propagating clockwise and anticlockwise around the helical thread. At the 12 o'clock position the crack jumped between adjacent threads to form a continuous crack. An area of mechanical damage/smearing was also evident on the fracture surface. A corresponding area of damage on the opposing fracture face indicated that this likely occurred as a result of relative movement between the two fracture faces during or after the final failure.

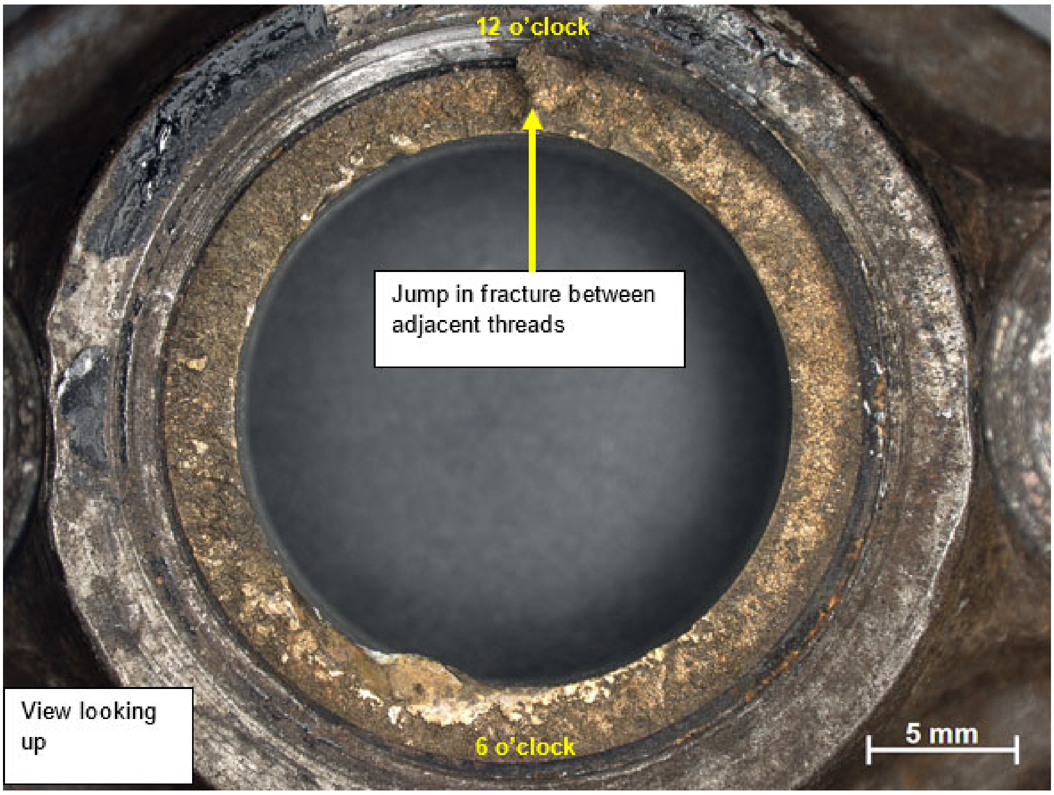

Figure 9

Fracture surface of the oil pipe at root of thread

SEM examination of the fracture surface showed extensive corrosion. Cleaning to remove the corrosion product only revealed a surface that had been attacked by corrosion and no real surface detail was visible. Shrinkage porosity was observed on the fracture surface. Shrinkage is a common defect found in cast materials, but without a specification for the casting, it was not possible to determine if the amount of shrinkage exceeded any specified limit. The presence of shrinkage porosity would reduce the load carrying capacity of the casting, and it is therefore possible that it contributed to the failure.

Between the 4 o'clock and 7 o'clock positions on the fracture surface, a band approximately 0.3 mm deep that contained ratchet marks was observed at the edge of the thread root. This band is identified by yellow dashed lines in Figure 10, and the ratchet marks as yellow arrows.

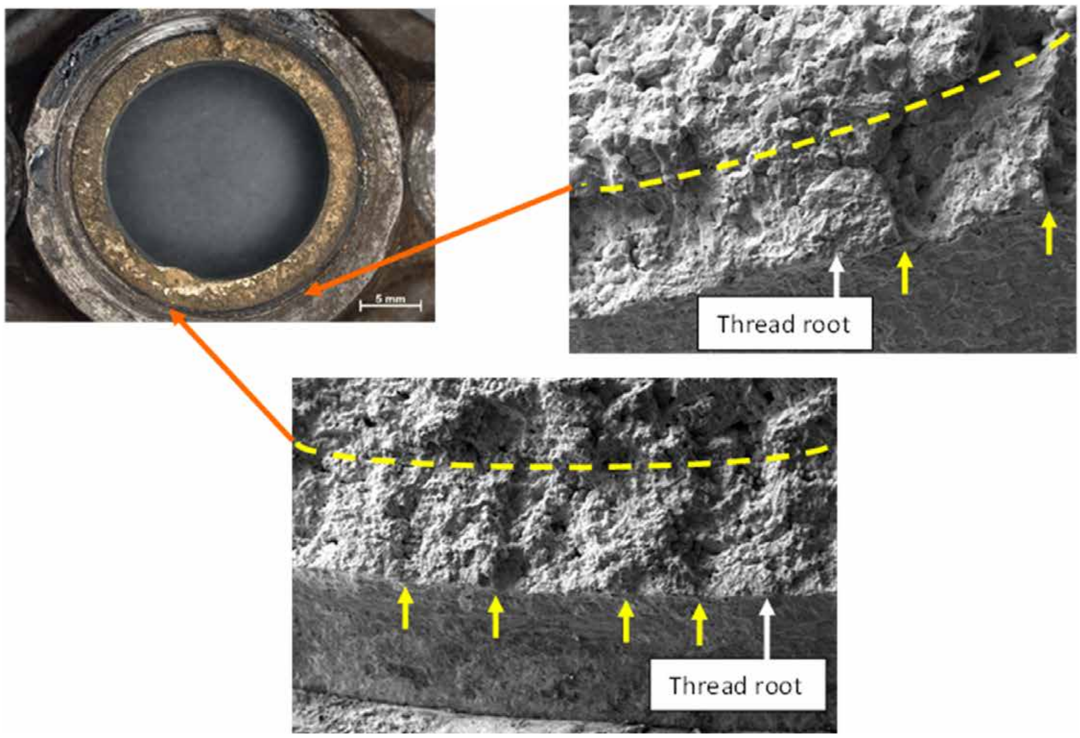

Figure 10

Fracture surface of the oil pipe at edge of thread root, showing ratchet marks in two example locations between the 4 o'clock and 7 o'clock positions

Ratchet marks are a characteristic of fatigue cracks and occur when cracks initiate at multiple points on different planes and then join to form a single crack front. Striation-like features were also observed within the 0.3 mm deep band. These features were consistent with fatigue striations and their orientation was consistent with fatigue initiating at the thread root. However, due to the extent of the corrosion it was difficult to positively attribute them to fatigue.

Aircraft maintenance

The operator's engineer considered that there was no reason for the oil inlet pipe connection to be disturbed, other than during an engine removal or installation, and he could not recall any maintenance in this area in recent years. Nor was anything relevant recorded in the engine or aircraft logbooks. He therefore considered that the oil pipe mounting boss and support strap would have last been disturbed in 2013, when the most recent engine replacement took place.

The aircraft was routinely disassembled, shipped by container and reassembled to fly at overseas air displays between 2014 and 2019. The oil and fuel were drained for shipping, but the oil system was not otherwise disturbed.

Although the area where the oil inlet pipe mounting boss and support strap connected to the engine casing had many pipes, accessories and engine bay structure present which may have obscured visibility, the engineer believed that he would have noticed the broken support strap had it been present on recent annual inspections. He advised that no torque limit was specified for the nut which held the support strap in place. During the aircraft examination, the torque to loosen the nut was noted as approximately 21 Nm.

The flexible and rigid sections of the oil inlet pipe were weighed, and the combined weight was found to be 1.54 kg.

Examination of other Stearman aircraft

There are five Stearman aircraft on the UK register equipped with the R-985 engine and at least one US-registered aircraft based in the UK. Of these six aircraft, three are known to have the modification for the larger oil tank in the baggage compartment, similar to N707TJ. Two are owned by N707TJ's operator, which, also owns a third R-985-engined Stearman that had retained the original 4 USG oil tank mounted on the firewall.

The oil system forward of the engine firewall was examined on the operator's three other R985-engined Stearman, to identify if there was potential for similar failures. The operator advised that when Stearman were historically retrofitted with the R-985 engine there was no standard manufacturer-approved modification, and the installation of the oil system could differ from aircraft to aircraft. Examination showed that the installation and support of the main oil inlet pipe was different on each of the operator's aircraft, and none had the exact same installation as N707TJ.

The oil inlet pipe on the first aircraft examined also comprised a flexible and rigid section of pipe. The rigid section, which also accommodated a port for the oil temperature probe and a 90º threaded joint, was similar in shape but much smaller and lighter than that on N707TJ. Two support straps supported the weight of the pipe (Figure 11).

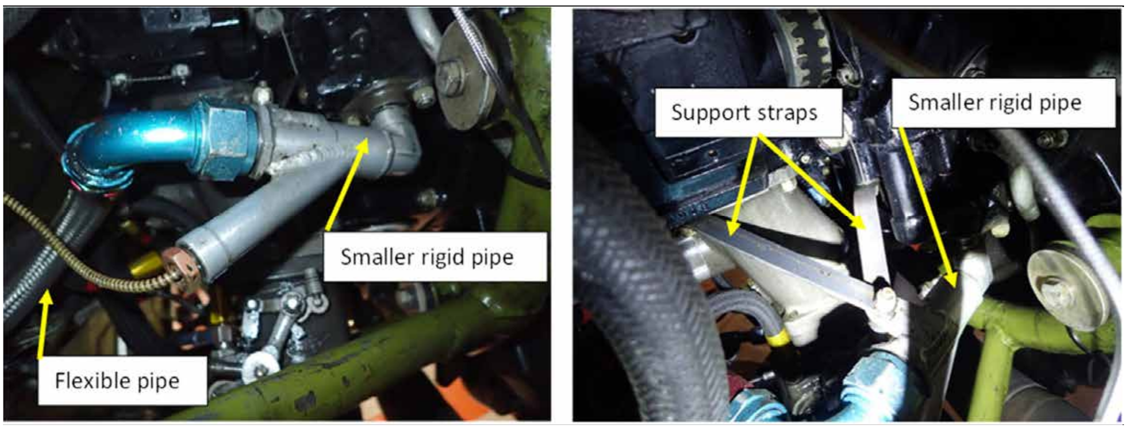

Figure 11

Alternative installation: smaller rigid pipe. Side view (left image), top view (right image)

The operator subsequently modified the installation on this aircraft to consist of a single flexible pipe and relocated the oil temperature probe.

The oil inlet pipe on the second aircraft was comprised only of a flexible pipe, which was shorter than that on N707TJ and a 90º threaded union (Figure 12). There were no supporting straps and the oil temperature probe was mounted separately.

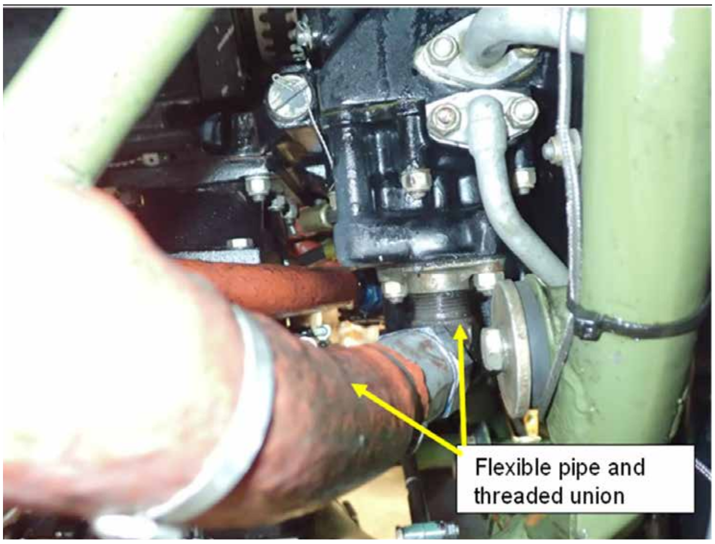

Figure 12

Alternative installation: flexible oil pipe and 90º threaded union, no support strap

The third aircraft, which had the original smaller oil tank mounted on the firewall had a flexible oil pipe which ran down from the oil tank, along the forward face of the firewall, into a Y-shaped union. From there a flexible pipe ran forward to the engine casing where it was attached to the mounting boss via a rigid 90º union. There were no support straps.

Safety and survivability aspects

Harnesses

Each seat in N707TJ was equipped with a 5-point seat harness connected to the seat and a secondary airline-style lap belt connected to the airframe. In addition, the wing walker wore a harness under her coverall, which attached to a safety restraint system and was used when the walker was outside the cockpit.

After the aircraft ditched, the pilot reported that he was able to unclip both his harnesses and escape without difficulty. The wing walker detached from the safety restraint system when she returned to the cockpit. She reported that although she struggled to exit the aircraft due to the shock of ditching, locating the seat harnesses was instinctive because of her training.

Head protection

There was no regulatory requirement for either of the occupants to wear a helmet. The operator informed the investigation that their standard practice was for both occupants to wear a helmet during transit flights. For display flights, the wing walkers would not wear a helmet as the operator considered that the weight and drag would place an extra strain on their body.

While there was padding around the sides of the cockpit, there was no padding on the coaming to provide head protection for the occupant (Figure 13). The operator explained that with the seat harnesses correctly tightened, it is not possible for the head to hit the coming or instrument panel.

Figure 13
Padding around the side of the front cockpit

Life jackets

Regarding this air display, the operator believed that wearing a life jacket could pose a potential hazard of becoming trapped in an inverted aircraft following a ditching and that there was less risk in not wearing a life jacket. This assessment was based on the time the aircraft would spend over the water during the display, and that it would be close to shore with safety vessels present to rescue the crew. It was also felt that wearing a life jacket would restrict the freedom of movement of the wing walker in climbing onto and off the wing.

Training

At the beginning of each season, training was undertaken by the wing walkers. This included familiarisation with the cockpit harnesses, the wing walker safety restraint system, and the brace position to be adopted during a crash or ditching.

Communication between pilot and wing walker

The aircraft was not fitted with any means for voice communication between the pilot and wing walker. Rocking the wings was the signal for the wing walker to look back to the pilot who would then communicate using pre-defined hand signals. The team reported that the moment either of the pilots deviated from the set display routine, the wing walker and the other pilot would recognise that there was something amiss.

The operator's 'Professional Wing Walker's Induction Guide' defined the hand signals to be used between the wing walker and the pilot but did not include any signals to be used in the case of an emergency. The wing walker reported that although she noticed when she returned to the cockpit that it was covered in oil, she had no means of informing the pilot.

As a result of this accident, the operator has introduced three new signals: expect a diversion; prepare for a forced landing / ditching and adopt the brace position; and for the walker to advise the pilot that there is fuel or oil in the cockpit.

Personnel

The pilot joined the operator in 2006. He was the lead pilot for the display team and had flown more than 900 displays. He held a UK Part-FCL PPL (A) with a valid SEP (land) class rating and a Display Authorisation (DA), which allowed him to act as formation leader and to carry out displays with an individual standing on the wing.

The wing walker had been with the team since 2018 and was the lead wing walker. This was her fourth display season with the team.

Ditching technique

The Pilot's Flight Operating Instructions for the Stearman provide no guidance on the technique for ditching. The pilot reported that prior to the flight he briefed the wing walker that in the event of a ditching he would fly as slowly as possible into wind just above the stall speed and 'pancake' the aircraft with the tailwheel touching first.

CAA Safety Sense Leaflet 21[3], extant at the time of the event, provided the following general advice to GA pilots on ditching and survival techniques:

> *'The force of impact can be high so ditch as slowly as possible whilst maintaining control…Hold the aircraft off the water so as to land tail down at the lowest possible forward speed, but do not stall into the water from a height of several feet…This main impact will usually result in considerable deceleration…'*

Following this accident, the CAA provided a routine update to Safety Sense Leaflet 21[4], which provides additional guidance on the technique to be used for ditching.

Analysis

Introduction

The loss of engine power, and subsequent ditching, was the result of a loss of oil supply to the engine. This occurred following a failure of the engine oil inlet pipe.

Footnote

[3] CAA Safety Sense Leaflet 21D '*Ditching*', dated January 2013, extant at the time of the accident.

[4] CAA Safety Sense SS21 '*Ditching Light Aircraft on Water*', dated July 2022. Available at https://publicapps.caa.co.uk/docs/33/SafetySense_21-Ditching.pdf [accessed August 2022].

Failure of the support strap

The steel support strap on the oil inlet pipe failed as a result of fatigue, which initiated at mechanical damage on the outer surface of the strap and propagated towards the inner surface. Normal engine vibration could have provided the cyclic loading mechanism to propagate the crack once formed. The function of the strap was to support the weight of the oil pipe. Once the strap had failed, the load would have transferred to the threaded joint on the pipe.

The size and shape of the witness marks associated with the mechanical damage on the support strap were consistent with its retaining nut having been over-tightened. It was not determined when this occurred, but there was no indication in the aircraft logbook that the oil pipe had been disturbed since the engine was replaced in 2013. It was not determined how long the aircraft may have flown with the support strap fractured, but nothing was noted during the recent annual inspection carried out several months before the accident.

Failure of the oil pipe

Examination of the fracture surface of the oil pipe threaded joint was less conclusive due to the extent of the corrosion, which likely occurred due to the aircraft's immersion in salt water. However, several features observed on the fracture surface, and the location of these features, were consistent with fatigue.

After the support strap failed, the weight of the oil pipe would have been taken solely by the threaded joint, leading to a stress concentration at the point of maximum tensile load. The final failure point, (at the 12 o'clock position), indicated by the crack jumping between adjacent threads, suggests that the crack initiated at or close to the 6 o'clock position (Figure 9). Examination around the 6 o'clock position, identified ratchet marks between the 4 o'clock and 7 o'clock positions.

The presence of ratchet marks, and their location at the edge of the thread root, combined with the striation-like features in the area where a fatigue crack would most likely initiate (around the 6 o'clock position), suggest that fatigue was the most likely cause of failure of the oil pipe. The presence of shrinkage porosity in the cast material of the threaded portion, would have reduced its load carrying capacity and may also have contributed to the failure.

No unusual oil leaks were noted on the engine prior to the accident. Photographs taken as the aircraft was landing after the previous day's flying display show no evidence of an oil leak, and no oil was noted on the ground during the pilot's pre-flight inspection on the day of the accident. It is therefore concluded that the final failure of the oil pipe occurred during the accident flight, although the crack may have been propagating for some time.

Other aircraft

The particular arrangement of the oil inlet pipe on N707TJ most likely arose from the need to re-route the oil supply when the larger oil tank was installed in the baggage compartment. Examination of the operator's other three R-985-engined Stearman aircraft (including two with a relocated oil tank) showed that there were a variety of possible installations for the oil inlet pipe. The installations on the other aircraft were different to each other and smaller/lighter than that on N707TJ, which made them less likely to suffer a similar failure. Nonetheless, the operator inspected the oil pipe installation on the other aircraft to satisfy itself that they were adequately supported.

Management of the emergency

The initial symptoms were that the aircraft was not climbing and the engine power was lower than expected. Consequently, the pilot abandoned the display with the intention of returning to the airfield without overflying populated areas and endangering third parties. As the emergency developed, the pilot declared a PAN and communicated his changing intentions. The involvement of the second aircraft in observing the event and declaring a MAYDAY, after N707TJ ditched, enhanced the overall understanding of the situation and ensured a rapid response from the emergency services.

With the FDD and representatives from the emergency services collocated in the MACC there was a joint understanding of the developing situation, which allowed a coordinated response. This included the tasking of the RNLI rescue boat, and paramedic, to shadow N707TJ and the subsequent transfer by ambulance to hospital.

The decision by the FDD to cancel the remainder of the flying display prevented subsequent aircraft from displaying before the fuel supply at Bournemouth Airport could be checked for contamination. It is also not unusual following an accident for other pilots and staff involved in the event to become unsettled and for safety resources to be out of position. Therefore, the cancellation of the flying allowed individuals to reconcile what had happened and provided the necessary time to reset the programme and ensure that the safety boats were in position.

Ditching

The crew had prepared for a ditching by briefing the technique to be used prior to the flight and by the wing walker rehearsing the brace position and the release of both seat harnesses during the preseason training. The video of the final stages of the flight showed the aircraft in a stable descent with the aircraft adopting a slightly nose raised attitude towards the end of the flight, followed by a controlled impact with the water. A ditching will result in a rapid deceleration and given the fixed landing gear it was almost inevitable that the aircraft would flip over.

While the wing walker banged her head during the ditching there were no medical reports of either crew sustaining an injury. A helmet would offer the wing walker additional protection, but the operator believed that this would be at the risk of possible injury due to the additional strain a helmet would place on the body while standing on the wing. The risk of a head injury was somewhat mitigated by padding down the edges of the cockpit, correctly fitted harness and the use of the brace position.

The operator considered that life jackets might impede the release of the seat harnesses and the escape from a submerged cockpit. It would also make it more difficult for the wing walker to get on and off the wing. Consequently, they were not worn. While not wearing a life jacket would have advantages during the evacuation, it would leave the occupants unprotected once in the water. The mitigation during the display was that organisers had several safety vessels situated around the display area who could quickly offer assistance; however, in this case the ditching occurred 3 nm from the display area.

Conclusion

The reduction in engine power occurred due to the failure of the oil inlet pipe, which resulted in the loss of the oil supply to the engine. The pilot was quick to respond to the situation and initially intended to return to the airfield avoiding high ground and populated areas. As the situation deteriorated, he continually revaluated his options and positioned the aircraft for a ditching that would reduce the risk to third parties. The pilot and wing walker were well rehearsed in handling emergencies and a successful ditching was carried out.

Following this accident, the operator introduced additional hand signals to enable the wing walker to inform the pilot of any oil or fuel leaks, and for the pilot to inform the walker that he intended to ditch.

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