ACCIDENT

Aircraft Type and Registration:	Cessna 172S, G-CBXJ
No & Type of Engines:	1 Lycoming IO-360-L2A Piston engine
Year of Manufacture:	1999 (Serial no: 172S8125)
Date & Time (UTC):	25 November 2019 at 1140 hrs
Location:	Near Puffin Island, Anglesey
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	79 years
Commander's Flying Experience:	More than 2,200 hours (hours on type not known)[1] Last 90 days – 4 hours Last 28 days – 1 hour
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was on a local flight when it descended into the sea, killing the pilot. No definitive cause for the accident could be found. There was no evidence of a structural failure leading to the accident and a trial to replicate the final flight profile discounted a full or partial engine failure. The trial concluded that it was likely the aircraft required an input on the controls in order to enter and maintain the recorded final descent path. The pilot had recently been unwell but there was no evidence of medical incapacitation, although this could not be dismissed as a possible cause.

History of the flight

The pilot arrived at Caernarfon Airport at about 0915 hrs on the day of the accident, having booked that morning to fly G-CBXJ with the flying club based at the airport. He planned to complete a local flight from Caernarfon out to Great Orme, a small peninsula about 24 miles along the coastline to the east, returning via Puffin Island off the north-east coast of Anglesey; a flight of about 30 minutes. The pilot checked the weather and booked out with the flying club before going out to the aircraft at about 0925 hrs. The engine, however, would not start.

Footnote

[1] The last record of the pilot's hours was a logbook completed in 2014 recording 2,200 hours total flying time. It is known the pilot had flown regularly since that time, including more recently on G-CBXJ, and flying club records were used to calculate his recent flying experience.

An engineer examined the aircraft and identified the starter motor shear pin had failed. Whilst the engineer worked on the aircraft, the pilot returned to the flying club where he talked to a number of people who described his demeanour as being normal. About an hour later the aircraft had been repaired and the pilot started the engine and taxied for takeoff, departing from Runway 07 at 1115 hrs.

Shortly after becoming airborne the pilot contacted Caernarfon Radio enquiring whether RAF Valley was open. Caernarfon Radio replied that it was and the pilot replied he was changing frequency to RAF Valley. The pilot contacted ATC at RAF Valley at 1126 hrs explaining he was on "a short trip to the Orme and back" asking for a Basic Service. RAF Valley ATC acknowledged his request.

The aircraft flew up the Menai Straits at about 1,400 ft amsl[2] and passed abeam Bangor at about 1130 hrs (Figure 1). The aircraft continued to follow the mainland coastline and climbed to 1,500 ft amsl as it turned left towards Great Orme, before turning left again towards Puffin Island.

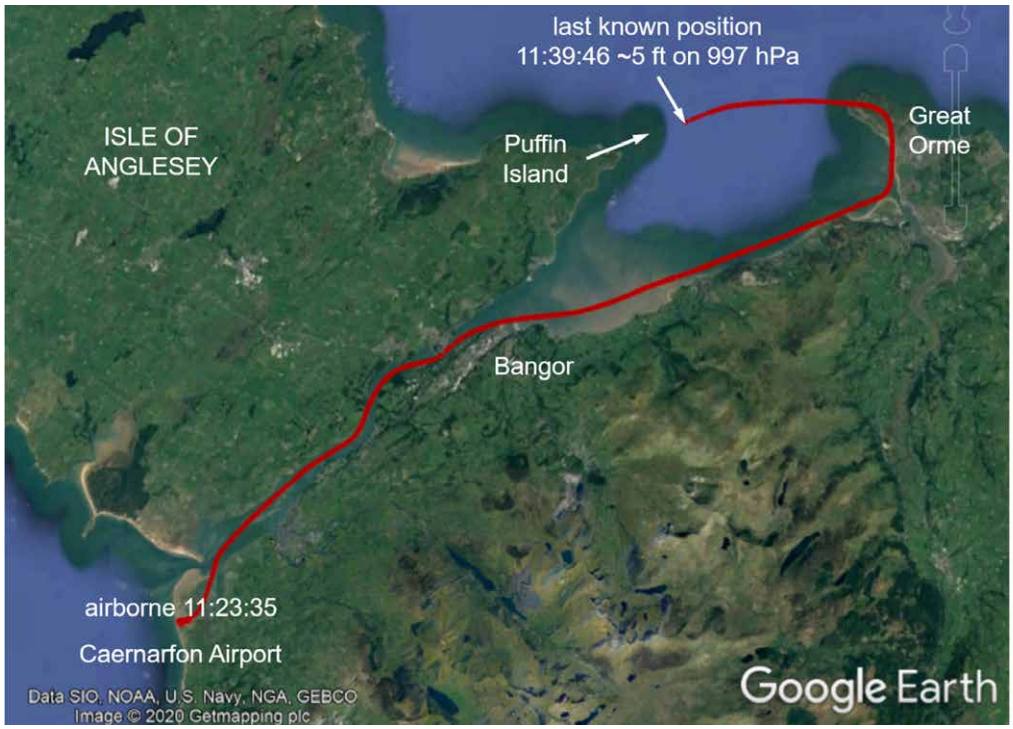

Figure 1
ADS-B[3] track of G-CBXJ

Footnote

[2] Aircraft are required to transit the Menai Straits below 1,500 ft on the Holyhead QNH.
[3] Automatic Dependent Surveillance—Broadcast (ADS–B) is a surveillance technology in which an aircraft determines its position via satellite navigation and periodically broadcasts it and other information, enabling it to be tracked.

Personnel at the flying club offices sometimes checked progress of flights using the Flightradar24 app[4] and at about 1205 hrs they looked to check the position of G-CBXJ, but could not see the aircraft on the live feed. They then searched the playback feature on the app which showed the aircraft apparently disappearing in the vicinity of Puffin Island. The flying club staff then asked Caernarfon Radio to put out a call to the pilot, but there was no response. Growing concerned, they phoned RAF Valley ATC which, at 1218 hrs, also tried to contact the pilot. Again, there was no reply and at 1235 hrs RAF Valley notified the Distress and Diversion Centre which initiated overdue action. A search was commenced using lifeboats and a search and rescue helicopter. Debris was found floating in an area north-west of Puffin Island later that afternoon.

Accident site

During the search for the aircraft, a lifeboat crew found the aircraft's right wing (Figure 2), part of the nose landing gear, a first aid kit and some personal effects floating in the sea approximately 3 miles north-west of Puffin Island. The wing was floating with its root up and photographs show that the leading edge had crumpled. An attempt by the lifeboat crew to recover the wing was abandoned when the wing came into contact with the lifeboat, puncturing the side. It was not found again and is thought to have later sunk. The other items were recovered back to shore.

After the immediate search and rescue attempts had been called off, a seabed search for the missing aircraft was commenced using vessels equipped with sonar. The search area was based on the last known ADS-B position, as well as calculations using the known currents and the time and position the floating wreckage was found.

The survey of the area found the wreckage of an aircraft, approximately one mile off the north-east tip of Puffin Island in about 27 m of water. The aircraft was not recovered, but video from a Remotely Operated Vehicle (ROV) subsequently confirmed the wreckage to be that of G-CBXJ.

Figure 2

Inboard end of the right wing found floating in the sea

Footnote

[4] A publicly available app using ADS-B technology and other transmissions to provide flight tracking and other information on aircraft.

The strength of the current and limited visibility meant a detailed survey of the wreckage by the ROV was not possible. However, the ROV was able to take video footage of much of the aircraft. This identified that, except for the right wing and engine, the aircraft was intact. The left wing's leading edge and lower surfaces were crumpled, consistent with a high-speed impact, but the aileron was still attached. The elevators were also still attached although the position of the trim tabs could not be established. The passenger compartment was severely disrupted and the engine was found lying detached next to the main wreckage.

Recorded information

The aircraft was not detected by primary or secondary radar as it was shielded from the only radar station in range, Clee Hill 90 miles to the south-west, by the Snowdonia Mountains. The aircraft was, however, fitted with an ADS-B Out capable Mode-S transponder[5] that broadcast the aircraft's identification, position, altitude, groundspeed and other performance data, at approximately 0.5 second intervals. These ADS-B broadcasts were detected and recorded by ground stations, in line of sight of the aircraft during the flight, that form part of the Flightradar24 ground network.

Figure 3 shows the aircraft's altitude (adjusted to the Holyhead QNH of 997 hPa) and groundspeed from the ADS-B Out broadcasts. Also plotted is the calculated true airspeed assuming a 15 kt southerly wind, which shows the aircraft flying at about 100 KTAS as it transited the Menai Straits and followed the coastline to the east.

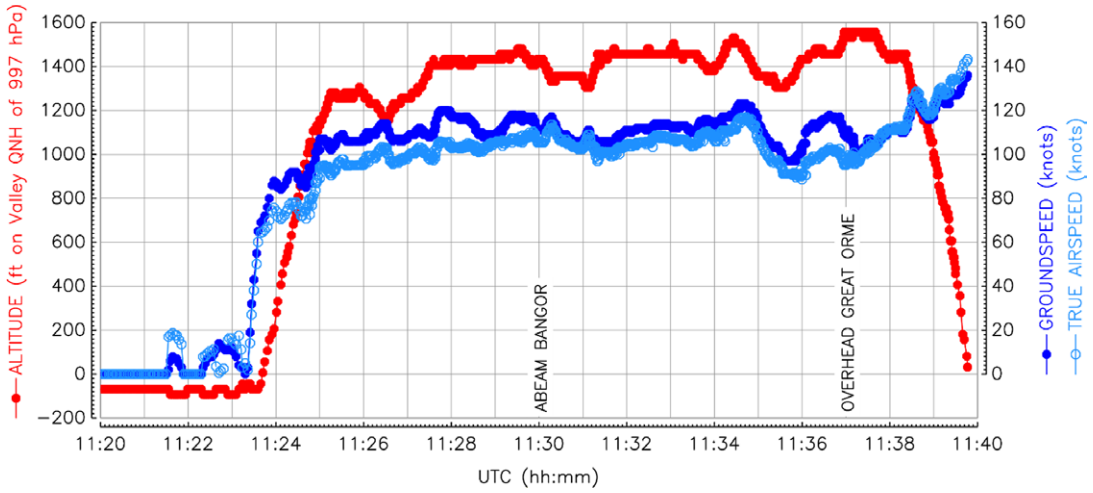

Figure 3

ADS-B data of accident flight

Figure 4 provides an expanded view of the data for the last two minutes of the flight starting as the aircraft crossed the Great Orme coastline heading toward Puffin Island. The aircraft's broadcast heading and climb rate are also plotted. This shows that after it headed west from Great Orme at 1,500 ft and 105 KIAS, the aircraft descended to 1,400 ft and accelerated to 110 KTAS before it turned left through about 7° towards Puffin Island. The

Footnote

[5] A transponder capable of transmitting data by ADS-B. In contrast, ADS-B In refers to a suitably equipped aircraft being capable of receiving and interpreting the broadcasts from other aircraft.

aircraft then descended again for about 90 seconds, initially at about 1,000 ft/min, during which it briefly levelling off at 1,200 ft. The last recorded point positioned the aircraft at a height of 5 ft over the sea on the Valley QNH of 997 hPa[6]. The descent profile shows the aircraft's rate of descent steadily increased, but fluctuated, reaching a peak of 1,700 ft/min, with a corresponding airspeed of about 140 KTAS. The data also shows that the aircraft turned slightly to the right by about 20° as it descended through 600 ft onto a final heading of about 245°M.

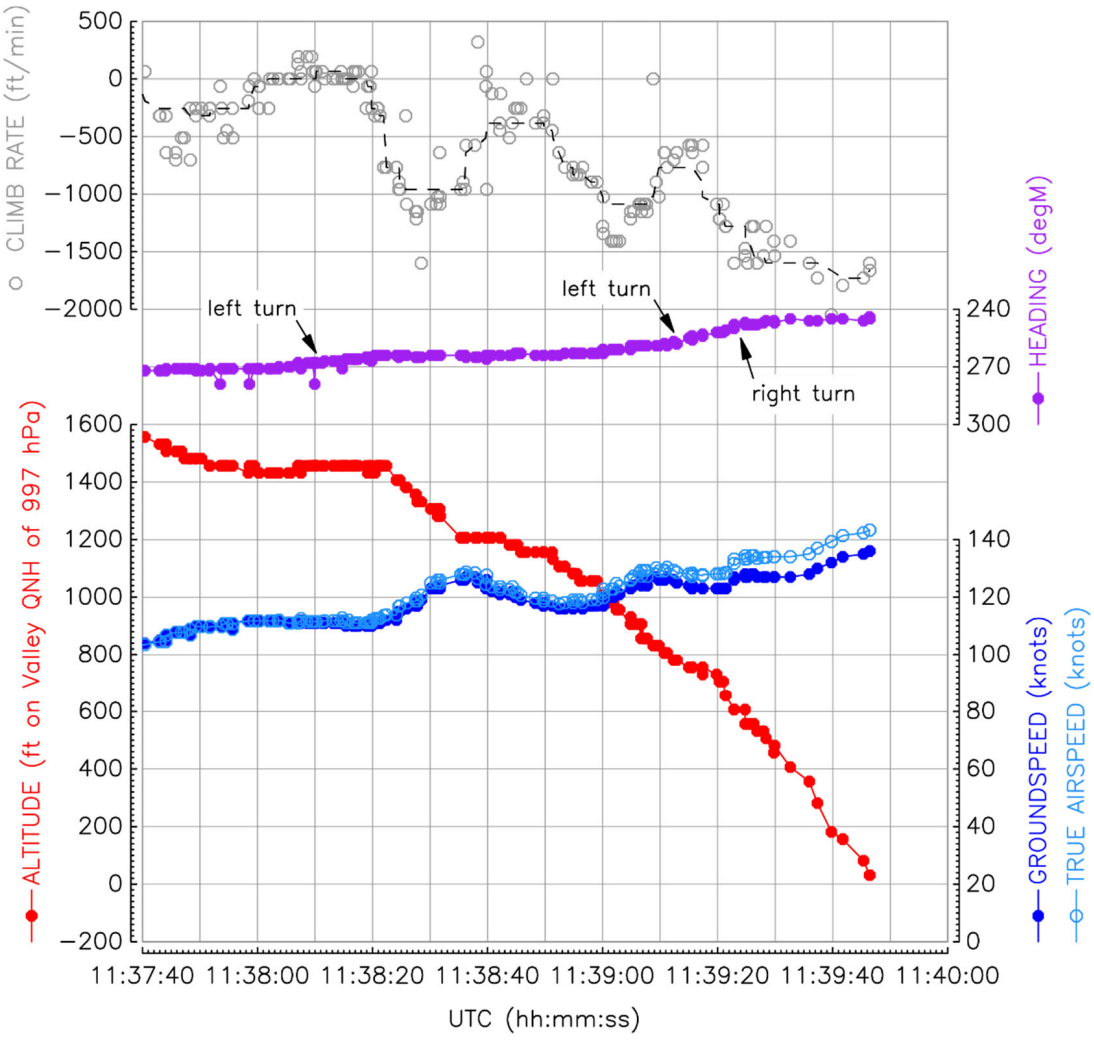

Figure 4

ADS-B data of the aircraft's descent from Great Orme coastline

Footnote

[6] ADS-B recorded an altitude for G-CBXJ on the ground at Caernarfon Airport prior to takeoff of -70 ft, when adjusted for the Valley QNH of 997 hPa. Caernarfon Airport has an elevation of 14 ft, giving a difference between actual altitude and recorded altitude of 84 ft. Therefore, the last recorded altitude during the flight could be as much as 89 ft amsl.

Aircraft information

The Cessna 172S[7] is a high-wing, four seat light aircraft powered by a Lycoming IO-360-L2A piston engine. It has a fixed tricycle landing gear and a two-bladed, fixed pitch propeller.

G-CBXJ had been maintained by an approved maintenance organisation in accordance with the manufacturer's service plan. The aircraft had recently undergone a 50-hour interval inspection, during which the directional indicator was replaced. The annual inspection and airworthiness review had taken place on 21 March 2019 and the aircraft had since completed 139 flying hours, having accumulated 6,072 flying hours from new at the time of the accident.

The aircraft was fitted with a manual pitch trim system and a single axis autopilot, although the autopilot was unserviceable at the time of the accident flight; the relevant circuit breaker having been pulled and appropriately placarded. There were no other known defects.

Pilot's background

The pilot had held a private pilot's licence since 1977 and had gained an instrument rating in 1983. He had renewed his instrument rating and completed a proficiency check on 17 August 2019. The pilot had previously owned his own aircraft for several years before selling it, after which he had flown regularly from Caernarfon in G-CBXJ. The route the pilot stated he was to fly was one he was known to have flown many times before.

Medical

The pilot held a valid EASA Class 2 medical certificate with a limitation requiring correction for defective near and distant vision. He had previously suffered from migraine but had not suffered an attack for over ten years. Medical opinion considered the circumstances did not support an incapacitating or distracting return of migraine, or a related condition called Transient Global Amnesia, as aircraft control and communications would likely to be wholly or partially preserved.

In the week prior to the accident, the pilot had complained of being unwell with a cough and cold for which he had self-medicated and spent 48 hours in bed. He had, however, recovered sufficiently two days before the accident to go out with a family member to watch a rugby match. During the car journey to the match, for which the pilot was a passenger in the car, he had complained of feeling 'strange' when the car had accelerated suddenly at one point during the journey. His family, however, thought he had recovered from his illness by the time he went flying and similarly found nothing unusual in his demeanour.

When the aircraft was located on the seabed, the pilot was found occupying the front left seat, secured by the seat harness. His body was recovered and a post-mortem examination and toxicology tests were carried out. Neither found any evidence of any medical condition which may have caused the pilot to become incapacitated during the flight.

Footnote

[7] Also known by its popular name, the Cessna 172 Skyhawk.

Weight and balance

The calculated takeoff weight for the aircraft using available weights for the aircraft, fuel and pilot, was about 2,072 lb, which was within the maximum permitted takeoff weight of 2,550 lb.

Similarly, the CG for the aircraft was calculated to be 39.8 inches aft of datum, this being within the permitted range of 36.4 – 47.3 inches aft.

Meteorology

Both Caernarfon and RAF Valley airfields were reporting generally good weather conditions at the time of the accident with visibility in excess of 10 km and a wind of between 7-11 kt from the south-east. There was broken cloud in the area with a base of 1,600-2,000 ft and showers to the south of Caernarfon, although these did not affect the route flown by the pilot prior to the accident. The temperature at Caernarfon was 12°C with a dew point of 10°C and a QNH for the area of 997 hPa.

Fuel

The aircraft was last refuelled on 17 November 2019 and had since completed three flights without incident. Flying school documents record there were 110 litres of fuel on board at the time it departed; sufficient for about 2 hours 15 minutes of flight.

Tests and research

Radio 'blind spots'

The aircraft operator carried out radio tests shortly after the accident to ensure that there were no radio 'blind spots' along the route flown which may have prevented any radio calls by the pilot being heard by RAF Valley ATC. No such 'blind spots' were found with the test radio transmissions all being heard.

Cessna 172S handling characteristics

As part of the investigation, a flight trial was carried out in another Cessna 172S to assess the likely handling qualities and performance of G-CBXJ and the inputs required to create its final descent profile. The flight was conducted with a similar takeoff weight and CG to G-CBXJ[8] by a qualified test pilot, using standard EASA CS-23[9] test techniques. The assessment specifically looked at the following:

1. *Descent from trimmed cruise* - to establish the force required on the control column (yoke) to make the aircraft descend at 1,000 and 2,000 ft/min from trimmed cruise;

Footnote

[8] The takeoff weight of the test aircraft was 2,300 lbs (estimate for G-CBXJ was 2,072 lbs) and the CG was 41.43 inches aft (estimate for G-CBXJ was 39.8 inches aft). The CG position of the test aircraft would have resulted in a negligible reduction in longitudinal stability over that of G-CBXJ.

[9] CS-23 is the EASA certification specification for normal, utility, aerobatic, and commuter category aeroplanes.

2. *Trimmed descent from cruise* - to establish the change of trim required from the cruise to a descent of 1,000 ft/min;

3. *Longitudinal stability long-period oscillation (phugoid)* - to establish the phugoid damping characteristics when the aircraft controls were released from an out-of-trim condition, and

4. *Lateral stability (lateral, directional and spiral)* - to establish the aircraft's weather-cock stability and response in the cruise when no inputs were made to the controls.

Handling test results

1. Descent from trimmed cruise

The aircraft was set up in the cruise with the engine at 2,500 rpm[10] in straight and level flight giving a speed of 110 KIAS. When trimmed, the trim wheel pointer was adjacent to the base of the letter 'A' in the vertically aligned words 'TAKE OFF' on the trim wheel indications. The aircraft was then put into a gentle dive by pushing the stick forward and a steady state 1,000 ft/min descent was established. A hand-held force gauge was used to measure force required to hold the control column in the required position.

In the descent, the engine rpm increased to 2,650 rpm and the airspeed to 135 KIAS, and a small push of about 2 kilogrammes force (kgf) was required to maintain the dive (this could be easily achieved by pushing on the yoke with a single thumb). When the descent was steepened to achieve 2,000 ft/min, the engine rpm increased further and the throttle had to be closed slightly to maintain 2,700 rpm, and the required push force increased to about 3.5 kgf.

2. Trimmed descent from cruise

When in the 1,000 ft/min descent, the 2 kgf force on the yoke could be trimmed out by moving the trim wheel (in a nose-down sense) so that the pointer moved from the base of the 'A' to midway through the 'A'. This corresponded to about 2 mm movement in the trim tab on the right-hand elevator trailing edge.

3. The longitudinal stability long-period oscillation (phugoid)

When the un-trimmed 2 kgf described above was released the aircraft's longitudinal stability caused the aircraft to pitch up and slow down. This pitch up excited the phugoid. The oscillation was allowed to continue for two full cycles and observed to be heavily damped with a period of 35-40 seconds (which is typical of this type of stable training aircraft).

Footnote

[10] The aircraft flight manual states a normal engine operating range (green arc) of 2,100-2,500 rpm and a maximum engine speed of 2,700 rpm.

Figure 5 plots the recorded data from the test aircraft for the phugoid. It shows that the vertical speed peaked at ±2,500 ft/min during the first oscillation with a corresponding change in altitude of ±300 ft. The airspeed varied ±25 KIAS and engine speed by about ±1,500 rpm.

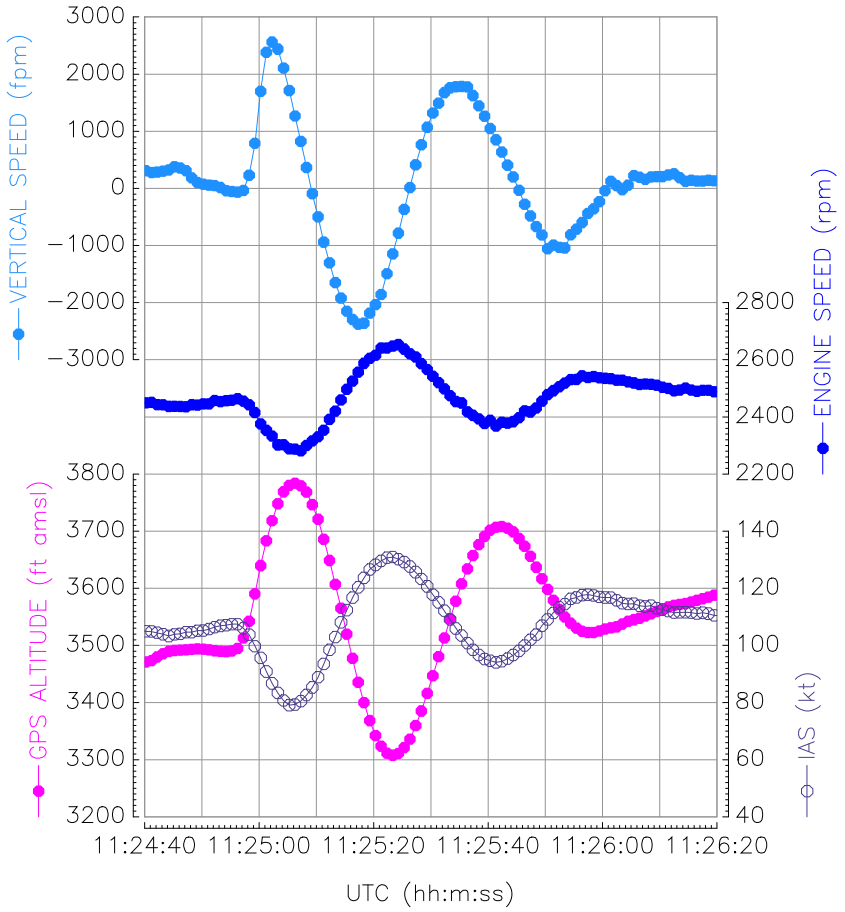

Figure 5

Test aircraft phugoid characteristics

4. The aircraft's lateral stability (lateral, directional and spiral):

Aileron only turns were flown in which the slip ball remained centred, indicating strong lateral stability (due to the wing dihedral). Equally, after initiating a rudder only turn, the aircraft rolled away from this sideslip condition, indicating strong directional (weather cock) stability.

When the aircraft was flown in the cruise stick free (hands off), the aircraft was reluctant to depart from wings-level flight. When encouraged by a small (2 cm) right rudder pedal input to simulate an out-of-trim condition or some turbulence, the aircraft began to roll slowly to the right. As the roll amplitude increased, the nose dropped and the airspeed progressively increased, resulting in a spiral dive within 10 to 15 seconds.

The results of the tests were supported by information provided by the aircraft manufacturer. This confirmed that the Cessna 172S is a stable aircraft design, but that the aircraft would tend to bank slightly to the right from straight and level flight if the controls were to be released. Should this occur then the aircraft would also start to descend and enter a spiral dive.

The manufacturer also reported that should the elevator have become disconnected, the CG would have caused the aircraft to enter a descent, but at a faster rate than that recorded.

Analysis

The review of the aircraft's maintenance records did not reveal any significant issues. The work carried out during the recent service and the repair to the starter motor just prior to the flight are unlikely to have resulted in any problems leading to a loss of power or inability to control the aircraft.

The flight trial also determined that the parameters required to recreate the final flight profile for the accident flight were consistent with the power being at a normal cruise power setting just prior to descent. The setting remaining unaltered for the subsequent descent, allowing the aircraft to accelerate and the rpm to increase due to the accelerating airflow through the propeller. This also indicates that the descent was not caused by a full or partial engine failure.

Whilst the right wing was found detached from the aircraft, the similar damage to both wing leading edges indicate that the aircraft was intact at the time it struck the water. The nature of the crumpling and buckling is consistent with the aircraft striking the water at high speed, with sufficient force to cause the right wing to detach. The separation of the nose landing gear from the airframe indicates that it was subject to significant force and it is considered the aircraft was pitched nose down with the wings approximately level when it hit the water.

Although the entire airframe could not be examined in detail by the ROV, from the available video it appeared that all the control surfaces were still attached. It would have been highly unlikely that the linkage to any of them would have become detached in flight. Had this happened it is expected the final flight path would have showed the aircraft maintaining a less stable flight path during its final descent.

The post-mortem and toxicology tests did not reveal any indication that the pilot had become incapacitated, although it is still possible that this had occurred. The pilot had been unwell in the days before the flight and his complaint of feeling uncomfortable when the car he had been travelling in had accelerated was unusual. His family had however considered he was well again at the time he went flying and saw nothing unusual in his behaviour.

Had the pilot become incapacitated during the flight it is likely he would have released the controls. The flight test demonstrated that the aircraft should then have entered a spiral dive rather than the near constant track descent seen on the ADS-B data.

Of note, it is probable that had a technical problem occurred, or the pilot suffered some kind of incapacitation such as a sudden migraine attack, the pilot would have attempted to notify ATC by radio.

Finally, the flight trial demonstrated that the aircraft's longitudinal stability resulted in a tendency to pitch up with increasing airspeed, requiring a small push force on the controls to achieve and maintain the descent as the aircraft accelerated. If the force was not held, the trim wheel would have had to be rotated slightly to increase the selected nose-down trim. The peak vertical speeds of ±2,500 ft/min of the phugoid during the trial flight varied only by ±250 ft/min from those seen during the accident flight descent, indicating that any phugoid motion would have been supressed by the pilot, either voluntarily or involuntarily. In assessing these results the test pilot concluded: "It is difficult to imagine a scenario where the trim could have been adjusted accidently or such a constant push force applied to the control column for 90 seconds or so without some deliberate action", and that "a lack of attention or pilot incapacitation would be very unlikely to lead to a wings level constant heading dive but would almost certainly lead to a spiral dive".

Conclusion

It has not been possible to identify a definitive cause of the accident. Whilst only a remote visual examination of the aircraft was possible, there was no indication of structural failure and the flight trial conducted indicated an engine failure had not occurred. The stability of the aircraft and evidence from the flight trial points to the need for an input on the controls, if only slight, to both enter and maintain a descent along a nearly constant track, as well as turning the aircraft left and then right towards the end of the descent. There was no evidence of medical incapacitation of the pilot, however, his recent illness and the fact that causes of incapacitation are not always evident means that this cannot be excluded.

Published: 29 October 2020.