ACCIDENT

Aircraft Type and Registration:	Silence Twister, G-JINX	
No & Type of Engines:	1 Ulpower UL260iSA piston engine	
Year of Manufacture:	2013 (Serial no: LAA 329-15102)	
Date & Time (UTC):	14 May 2017 at 1330 hrs	
Location:	MOD Abingdon, Oxfordshire	
Type of Flight:	Commercial operation	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - 1 (Serious)	Passengers - N/A
Nature of Damage:	Aircraft and engine severely damaged	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	49 years	
Commander's Flying Experience:	1,154 hours (of which 259 were on type) Last 90 days - 15 hours Last 28 days - 13 hours	
Information Source:	AAIB Field Investigation	

Synopsis

During a formation aerobatics display of a pair of aircraft at MOD Abingdon the engine of the number 2 aircraft lost power and then stopped in flight. The subsequent attempted forced landing onto the runway at Abingdon was unsuccessful.

The investigation found that the engine seized following the loss of its oil during the accident flight.

Several safety actions have been taken by the engine manufacturer, the owner, and the Light Aircraft Association.

History of the flight

The accident aircraft was the following or 'number 2' aircraft[1] in a formation of two Silence Twisters that were scheduled to fly a formation aerobatic display at the Abingdon Air and Country Show, at MOD Abingdon, Oxfordshire.

The two aircraft flew from their base in Buckinghamshire and landed at Abingdon prior to their display. During the preparation for the display, the pilot of G-JINX checked the engine's oil quantity and found it was indicating full.

Footnote

[1] Aircraft flying in formation may be numbered according to their position in the formation. The formation leader is number '1' and subordinate aircraft are numbered '2' onwards.

As the aircraft from the previous display positioned to land, the two Silence Twisters took off in formation, and were cleared to commence their display by the display controller once these aircraft had landed. At the time the weather was fine with wind from 260° at 12 kt. Runway 18 was in use with the western side of the runway established as the 150 m crowd line[2] (Figure 1).

The first few minutes of the display proceeded without incident. However, the accident pilot became aware that G-JINX's engine appeared to have been underperforming during the 'barrel' rolls that formed the second manoeuvre in the display sequence, and transmitted to the leader to reduce power slightly because he was unable to maintain the correct formation position.

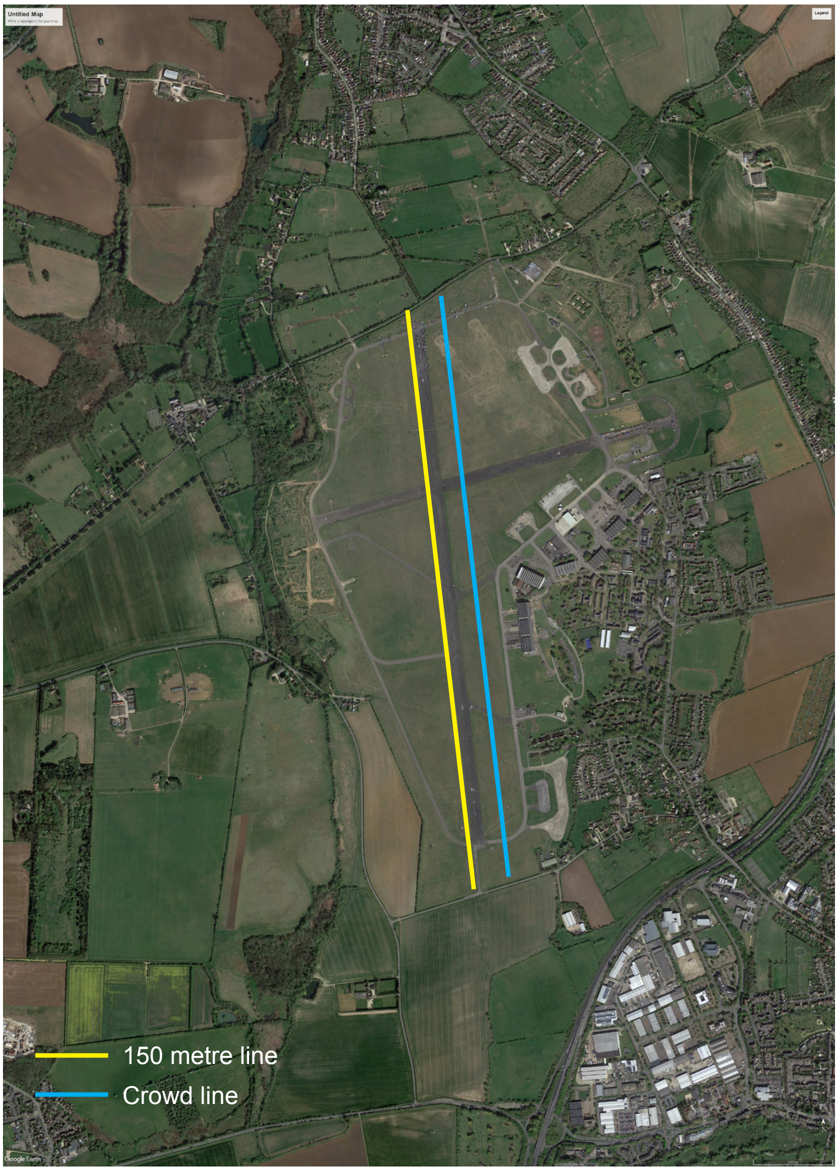

Figure 1

Overview of MOD Abingdon Airfield

Footnote

[2] 150 m is the minimum distance from the crowd line that display aircraft, with a MTOM less than 1,200 kg and speed less than 150 KIAS, are permitted to fly, in accordance with CAP 403.

After the next manoeuvre, a stall turn, the leader transmitted "ARE YOU GOING TO BE OK…YOU'RE A BIT LOW" to which the accident pilot replied "I AM VERY LOW ON ENERGY HERE" followed a few seconds later by "I'VE GOT A PROBLEM, I'M LANDING OFF THIS [manoeuvre]". At this point G-JINX was downwind, about half way along Runway 18, approximately 200 ft aal and 200 m displaced from the runway's centreline. The pilot then converted the aircraft's remaining excess speed to height and momentarily turned left, to try to displace the aircraft further away from the runway. Whilst the engine was still running the pilot commenced a tight descending right turn to align with the runway. During the turn the engine stopped. The aircraft struck the grass to the east of the runway, with its landing gear and flaps retracted, in a wings-level and slightly nose-down attitude. The aircraft bounced and slid to a halt. The formation leader, who was unaware of the accident, continued with the display.

Figure 2

G-JINX after accident
(Picture courtesy of Peter Thomas)

The display controller declared an aircraft accident and sent all on-site rescue resources to the scene, the first arriving within 50 seconds of the aircraft coming to a halt. The pilot was found slumped forward in the cockpit unconscious. The RFFS could not find a way to open the canopy and, as the pilot's head was very close to the canopy, did not want to break it. The pilot then regained consciousness and opened the canopy from the inside. He was subsequently lifted out of the aircraft and taken to hospital where it was discovered he had sustained serious injuries.

Accident pilot's comments

The pilot of the accident aircraft commented that the difference in performance between the two aircraft, that he experienced during the barrel rolls and the quarter clover, was not unusual. He had experienced comparable differences, with some difficulties staying in position, during previous displays. He added that it is a "subtle art" to remain in close formation given that the aircraft's engine has 107 hp.

The pilot commented that he made a “quick scan” of the engine instrument after the barrel rolls, when he was not close to the leader, and during the time that he closed back into the correct position before the next manoeuvre, noting that all engine parameters were within limits. However, he became aware he had an engine problem during the stall turn. At the end of this manoeuvre the engine was still turning and producing power, and despite a brief glance at the instruments, the pilot did not notice any engine warnings. He added it was possible he may have missed any warnings during the ‘glance’, as most of his attention was outside of the cockpit as he subsequently concentrated on the landing the aircraft.

Having elected to discontinue the display the pilot made a quick assessment of potential landing options. However, given his low height and proximity to the runway, and with no suitable options ahead or to the left (ie away from the crowd) due to wooded areas and villages, he elected to attempt to land on the runway. At that point the engine was still turning but its power was reducing rapidly. The pilot believed the engine stopped about 2 to 3 seconds before the impact.

The pilot recalled that he flew a tighter turn than he would have wished due to the limited lateral offset available to line up with the runway and the presence of the crowd line beyond. He commented that there is an imperative placed upon display pilots not to breach the separation distances from the crowd.

Aircraft information

General

The Twister is classed as a ‘Group A’ aircraft and the basis for its design approval is the EASA Certification Specification for Very Light Aeroplanes (CS-VLA). A Type Approval (TADS 329) was issued by the Light Aircraft Association (LAA).

G-JINX was registered on 14 October 2011 and was operated on a CAA Permit to Fly administrated by the LAA. The last Certificate of Validity was issued on 6 April 2017 and was valid until 5 April 2018.

Aircraft

The Twister is a single-seat, low-wing aircraft fitted with conventional flying controls, a retractable landing gear and flaps. The aircraft is constructed from honeycomb composites, reinforced with carbon and glass fibre, and incorporates a cockpit safety cell manufactured from Kevlar. The aircraft has a safe load factor of +6/-4g at the maximum takeoff weight at a manoeuvre speed of 98 kt. The pilot sits in a reclined position on an energy absorbing seat cushion and is secured by a four-point harness and a separate lap strap.

Canopy

The aircraft is equipped with a one-piece bubble canopy hinged along the right side. The canopy is unlatched by operating a white handle on the left side of the cockpit (Figure 3). To jettison the canopy, the white handle must be operated at the same time as a second black handle on the right side of the cockpit, which removes the pins from the canopy hinges (Figure 4).

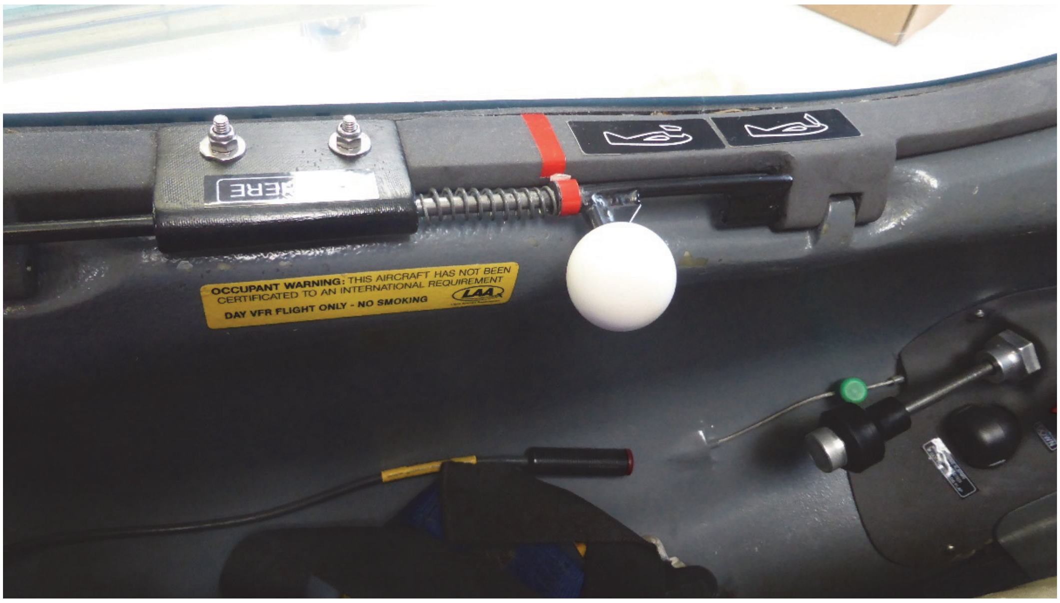

Figure 3

White canopy opening handle

Figure 4

Black canopy jettison handle

There are no canopy opening or jettison handles on the outside of the cockpit; however, it can be unlatched by reaching through the small ventilation window and operating the white handle (Figure 5). There were no instructions visible from outside the cockpit explaining how the canopy is opened.

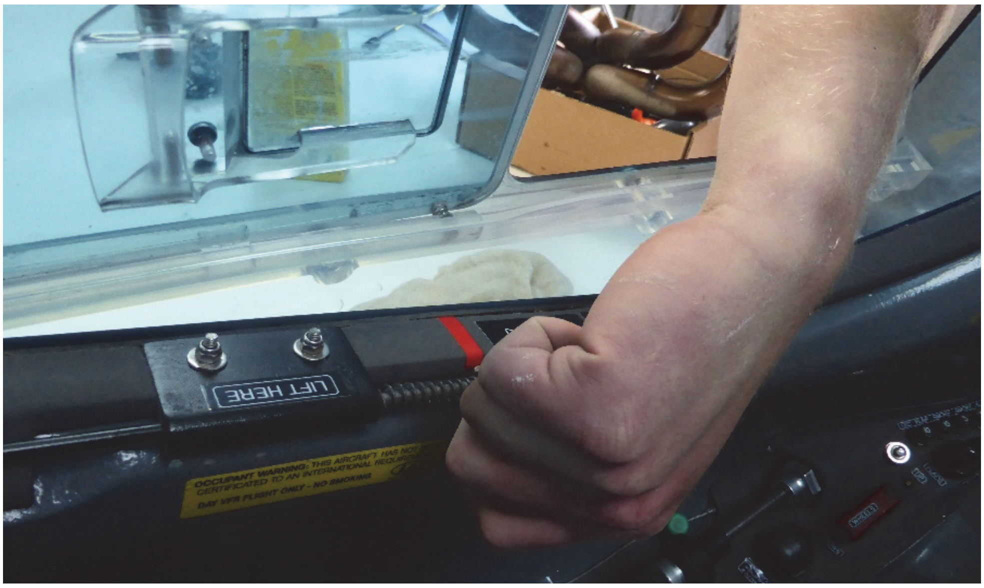

Figure 5

Opening the canopy from outside of the cockpit

The CAA advised that the Certification Specifications (CS) for Very Light Aeroplanes (CS-VLA) may be considered as guidance for the Silence Twister. Article 807 refers to emergency exits, Article 1541 to markings and placards, and Article 1555 to control markings:

> *'CS-VLA 807, Emergency exits*
>
> *(b) The opening system must be designed for simple and easy operation. It must function rapidly and be designed so that it can be operated by each occupant strapped in his seat, and also from outside the cockpit…*
>
> *CS-VLA 1541, markings and placards General*
>
> *(b) Each marking and placard …*
>
> *(1) Must be displayed in a conspicuous place …*
>
> *CS-VLA 1555, control markings*
>
> *(d) When an emergency exit is provided in compliance with CS-VLA 807, each operating control must be red. The placards must be near each control and must clearly indicate its method of operation.'*

The cockpit and canopy on the Twister is similar to that used on sailplanes, which are required to conform to CS-22. Article 22.780 details the colour markings and arrangement of the cockpit controls and specifies that the canopy operating handle should be white and the jettison handle red. It also states that if the opening and jettison handle are combined in one handle then the colour must be red.

The Silence Twister is not required to conform to these specifications.

Avionics

G-JINX was one of three aircraft built from a kit by the current owner and was fitted with a Dynon Avionics EFIS-D10A (Electronic Flight Information System) ADAHRS[3] that incorporated the engine and fuel sensors, and EMS-D10 (Engine Monitoring System) that incorporated the engine and fuel sensors. The EMS constantly monitors several parameters and displays the value as a number and position on a digital gauge. When the parameter is within the normal operating range the needle, or indicator on the digital gauge, will be in the green range. If the parameter is outside of the normal operating range then a yellow or red alert will be generated. This is indicated to the pilot by the background to the numerical value flashing yellow or red. The red alert is also accompanied by a red message across the bottom of the screen. The EMS was capable of producing an audio alert to the pilot, through the intercom, but this function was not enabled at the time.

Display smoke

G-JINX was fitted with a tank, located behind the pilot's seat, which contained the oil that was injected into the exhaust pipe during the display to produce smoke.

Engine - general

G-JINX was fitted with a 107 HP, UL260iSA four cylinder, air cooled, four stroke piston engine and a two blade fixed pitch propeller. The UL260iSA is a modified version of the UL260iS engine developed for use in aerobatic aircraft. The cylinders are numbered as shown in Figure 6 with cylinders 3 and 4 at the rear of the engine.

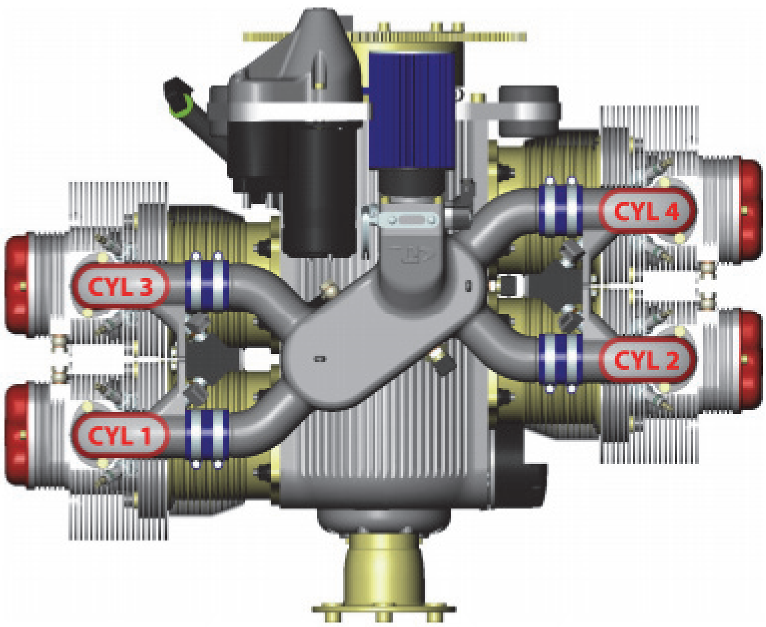

Figure 6

Numbering of engine cylinders

Footnote

[3] Air Data, Attitude and Heading Reference System.

The engine is equipped with a dual electronic ignition and a multi-point fuel injection system controlled by an Electronic Engine Management System (EEMS). Prior to the accident involving G-JINX, the engine operating manual stated that the engine was permitted to run on unleaded automotive fuel (MOGAS) with a minimum octane rating of 98 RON, or AVGAS 100LL if the specified fuel was not available.

The engine operating manual stated that the UL260iS variants can be run at the maximum power setting of 107 hp at 3,300 rpm for five minutes, and for an unlimited period at the maximum continuous power setting of 95 hp at 2,800 rpm. The engine manufacturer advised the AAIB that providing the other engine parameters are within limits, the engine can be operated at the maximum power setting beyond the specified limit of five minutes.

Engine – aerobatic variant

The UL260iSA engine is a modified version of the UL260iS engine where changes have been made to the engine casing, oil sump and oil 'pick-up' system to allow the engine to be flown inverted for extended periods. The owner of G-JINX worked with the engine manufacturer in developing the aerobatic variant of the engine and was the first customer to fit this variant to his aircraft. At the time of the accident, several hundred UL260iS engines and between12 and 15 UL260iSA engines were in service.

The owner of G-JINX had four aerobatic engines which he rotated between his three Twister aircraft that he used for the aerobatic displays. The engine fitted to G-JINX had completed 676 engine hours and was thought to be the fleet leader. The other three engines had accumulated 198 hours, 523 hours, and 540 hours respectively.

Engine – oil system

The engine oil system is equipped with two oil inlet pipes, with one pipe fitted at the top and one fitted at the bottom of the engine. Both pipes are connected to an 'inverted oil valve', which consists of a valve body with three ports and two steel balls kept apart by a spring. Gravitational forces act on the steel balls, which move against the springs to uncover and close the oil inlets at the top and bottom of the engine. The inlet pipe at the bottom of the engine is fitted to a swivel coupling, which can rotate rearwards by 60˚ and forward by 30˚, to ensure that the mouth of one of the inlet pipes is always submerged as the pitch attitude of the aircraft changes.

The oil breather system incorporates an oil separator tank which is connected by flexible inlet breather pipes to the top and bottom of the engine. A separator tank is also connected to the engine exhaust by the exit breathe pipe. A valve within the separator tank, operated by gravitational forces, opens and closes the inlet breather valves depending on the attitude of the aircraft. Oil collected by the separator is retained in its tank and the air is discharged through the exit breather pipe to the engine exhaust. The owner reported that it is normal for a small amount of oil to be discharged into the exhaust when the aircraft transitions from erect to inverted flight.

The engine oil is cooled by an external oil cooler mounted at the front of the engine. The minimum and maximum oil levels for the engine are 2.5 and 3.5 litres. The normal oil pressure depends on the oil temperature, but should be between 30 and 75 psi. The engine operating manual states that the engine should not be operated if the oil pressure is below 14.5 psi. On G-JINX, the owner had set the EMS to generate warnings when the oil pressure was between 20 and 27 psi (yellow warning) and below 20 psi (red warning).

Engine – cooling

The engine is cooled by ambient air and engine oil. Ambient air is directed through two inlets at the front of the engine cowling and is guided by ducts over the cylinder heads and the upper part of the cylinders.

At an engine speed of 3,000 rpm, the oil flows through the engine at approximately 24 litres per minute. This oil is directed to the crankshaft, camshaft, and rocker arms to provide lubrication and cooling. The oil leaving the crankshaft and conrod bearings is directed to the bottom of the pistons where a mist of oil is created that lubricates the piston walls and cylinder bores.

The manufacturer advised that it is not unusual for the two rear cylinders (numbers 3 and 4) to run slightly hotter than the front cylinders.

Flight manual

The aircraft's flight manual states that the minimum speed with flaps retracted is 44 kt (V_s). It also states the following in the section on emergency procedures:

'Emergency landing with stopped engine

1. *Airspeed 65 kts*
2. *Make Mayday radio call*
3. *Fuel selector valve closed*
4. *Ignition off*
5. *Lower the undercarriage (if landing area is uneven or soft, land with undercarriage retracted)*
6. *Flaps as necessary (30° is recommended)*
7. *Main switch off (when landing is absolutely certain)'*

Aircraft examination

The aircraft and engine were initially examined by the AAIB at the owner's workshop after he had moved the aircraft, with the permission of the AAIB, from the accident site. The engine was dismantled under the supervision of the AAIB and returned to the manufacturer for a more detailed examination.

Aircraft

The airframe and wings were damaged during the impact; however, the canopy, cockpit area and fuel system remained intact. There was sufficient fuel in each of the two fuel tanks for the aircraft to have completed the flight. Both electric fuel pumps operated normally, the fuel was clear and there was no evidence of debris in the gascolator.

The EEMS, EFIS, and EMS operated normally when electrical power was applied to the aircraft.

The outlet pipe from the display smoke oil tank fractured during the accident allowing oil to leak into the cockpit area.

Engine

The oil cooler had been damaged during the accident and the owner reported that the engine oil had leaked out subsequently. When the AAIB examined the engine, the oil level did not register on the dipstick. There was no evidence of an external oil leak other than from the oil cooler.

The engine could not be rotated by hand. Externally there was no obvious damage other than to the oil cooler and propeller. On removing the cylinder heads it was discovered that the No 3 piston had been badly damaged and a significant section had broken away (Figure 7). There was no evidence of detonation or cracking of the piston. The inside of the cylinder was dry, and marks on the side of the piston and inside of the cylinder bores indicated that the piston had seized in the cylinder. The piston rings and scraper had all been damaged. The remaining three cylinders were also dry and there was damage to the sides of all the pistons and cylinders indicating that the pistons had expanded and had started to 'grab' the side of the cylinder.

Figure 7
Damage to No 3 piston and cylinder

The spark plugs, piston and cylinder heads were a light grey in colour indicating that the engine management control system and spark plugs had operated correctly. The connecting rod bearing shells showed signs of wear and slight damage. The piston pins and conrods all had a blue tint which is an indication of overheating. The cooling vanes adjacent to the cylinder head securing bolts were slightly distorted, which normally indicates that the cylinder has overheated.

A thorough examination of the oil system was carried out. The oil pump drive was intact, the pump was free to rotate, the filter was clean, and there were no blockages in any of the oilways or pipes. The amount of oil in the breather separator tank was not excessive. As far as could be ascertained, all the oil system components operated satisfactorily and the AAIB could identify no path for the oil to have been lost from the engine other than through the breather system or past the damaged No 3 piston.

In summary, the damage to the engine was consistent with a loss of lubrication, and cooling, which resulted in the pistons expanding and seizing in the cylinders.

Maintenance

Based on information from the owner, the accident flight met the description in Article 11 of the Air Navigation Order as being non-commercial. Therefore, it was acceptable for the aircraft to be used for public air displays while operating on a Permit to Fly and being maintained in an airworthy condition. The LAA offers advice to its members as to how this might be accomplished by the use of their Generic Maintenance Schedule to help owners produce a tailored maintenance schedule.

While the UL260iS engine had a recommended Time Between Overhaul (TBO) of 1,500 hours / 12 years, the manufacturer had introduced an initial TBO of 250 hours / 4 years for the aerobatic version of the engine, the UL260iSA.

The engine fitted to G-JINX had experienced several faults during its service history, which seemed to increase in frequency after the aircraft sustained an airborne propeller strike at 464 engine hours (Table 1). The maintenance to correct these faults was carried out by the owner, who was an LAA inspector and authorised to inspect this work and sign the Permit Maintenance Release.

The manufacturer informed the AAIB that the same design of piston was used in all of its high compression engines[4] and it was only aware of the one occurrence of a piston cracking. On 5 March 2016 the manufacturer advised the owner of G-JINX to replace the pistons every 250 hours on aircraft used for aerobatic flights.

Footnote

4 Around 400 high compression engines had been delivered at the time of the accident.

Engine Hours	Date	Event
0	2009	The engine, manufactured as a UL260iS variant, was fitted to G-RIOT.
225	July 2010	A larger oil cooler was fitted to the engine by the owner.
286	Oct 2010	The engine was returned to the manufacture for conversion to the aerobatic version, UL260iSA.
292	July 2011	The engine was returned to the manufacturer for a new, modified, crankshaft to be fitted.
404	July 2012	The compressions on #3 and #4 cylinders were found to be low. The owner replaced both cylinder heads and the #3 cylinder.
464	Aug 2013	The engine was returned to the manufacturer for an inspection following an airborne propeller strike, while fitted to G-ZWIP, and then fitted to G-JINX.
483	May 2014	The #1 piston was found cracked. The piston and cylinder were replaced by owner.
530	July 2014	The owner found a suspect crack on the #4 piston. The #2, #3, #4 pistons and cylinders were replaced as a precaution by the owner. A subsequent inspection by the manufacturer found no evidence of a crack on the #4 piston.
530	July 2014	The engine was examined by the manufacturer following the suspected cracked piston.
533	Sep 2015	The oil temperature was reported to be high, but within limits, during a transit flight. The thermostat in the oil cooler was replaced.
609	July 16	The compressions on all four cylinders were found to be low. All four cylinder heads were replaced by the owner.
676	Nov 16	The compressions on the #1 and #3 cylinders were found to be low. Both cylinder heads were replaced by the owner.
683	May 17	The engine seized in flight while the aircraft was flying an aerobatic display.

Table 1

Service history of engine fitted to G-JINX

Recorded information

The EMS and EFIS were recovered from the aircraft and their memory downloaded. The EMS memory contained engine data such as oil temperature and pressure, engine rpm and cylinder head temperatures (CHT), recorded approximately every 10 seconds. The EFIS memory contained flight data such as altitude, airspeed, pitch attitude and heading, also recorded approximately every 10 seconds.

Figure 8 shows flight data from the EFIS starting as the aircraft descended to the start the display sequence and ending with the aircraft on the ground. EFIS times have been adjusted to align them with EMS. Figure 8 shows when the oil pressure dropped below 20 psi (generating an EMS low pressure warning – also plotted with engine rpm from EMS), the point in the flight where G-JINX performs a stall turn and when (based on timing from video evidence) it struck the ground 32 seconds later.

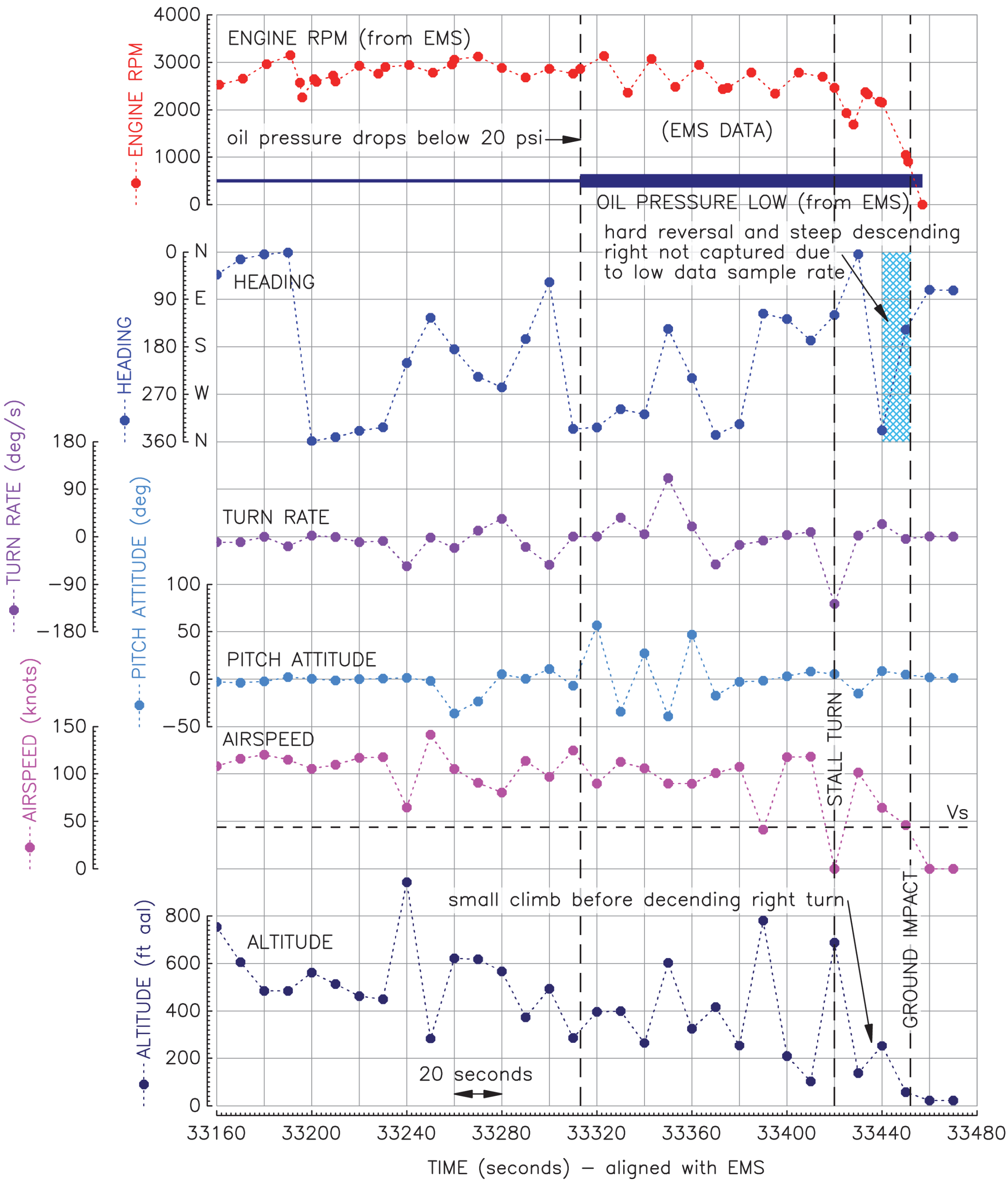

Figure 8
EFIS recorded flight data – accident flight

From video evidence, the right turn and descent to ground impact took 12 seconds, so are not evident in the EFIS data because of the low data sampling rate. However, the turn was through about 180° initially at 65 kt airspeed at about 250 ft aal. During the first half of the turn the bank angle was held at about 45° without significant height loss. The aircraft then began to descend as the bank angle increased and the nose dropped (Figure 9). At just under 60 ft aal the airspeed had reduced to 46 kt, after which the wings were levelled and the nose was raised to a slightly nose-down attitude at impact.

Figure 9

G-JINX shortly before ground impact
(Picture courtesy of Peter Thomas)

Figure 10 shows relevant engine data from the EMS. It indicates that the time between the increase in engine speed (time 33030, which corresponded to the start of the takeoff roll), and the low oil pressure warning was 4.8 minutes. During this period, as the oil temperature increased and the oil pressure decreased, engine rpm varied around 2,800 rpm (maximum continuous) and peaked briefly at 3,151 rpm. The CHTs also increased with the No 3 cylinder operating between 20 and 30ºF hotter than the hottest of the other three cylinders (cylinder No 4). After approximately 4 minutes, the oil pressure had decreased to 30 psi. It then continued to decrease below 20 psi, generating the low pressure warning and reaching zero one minute later. The engine continued to rotate for a further 1.5 minutes.

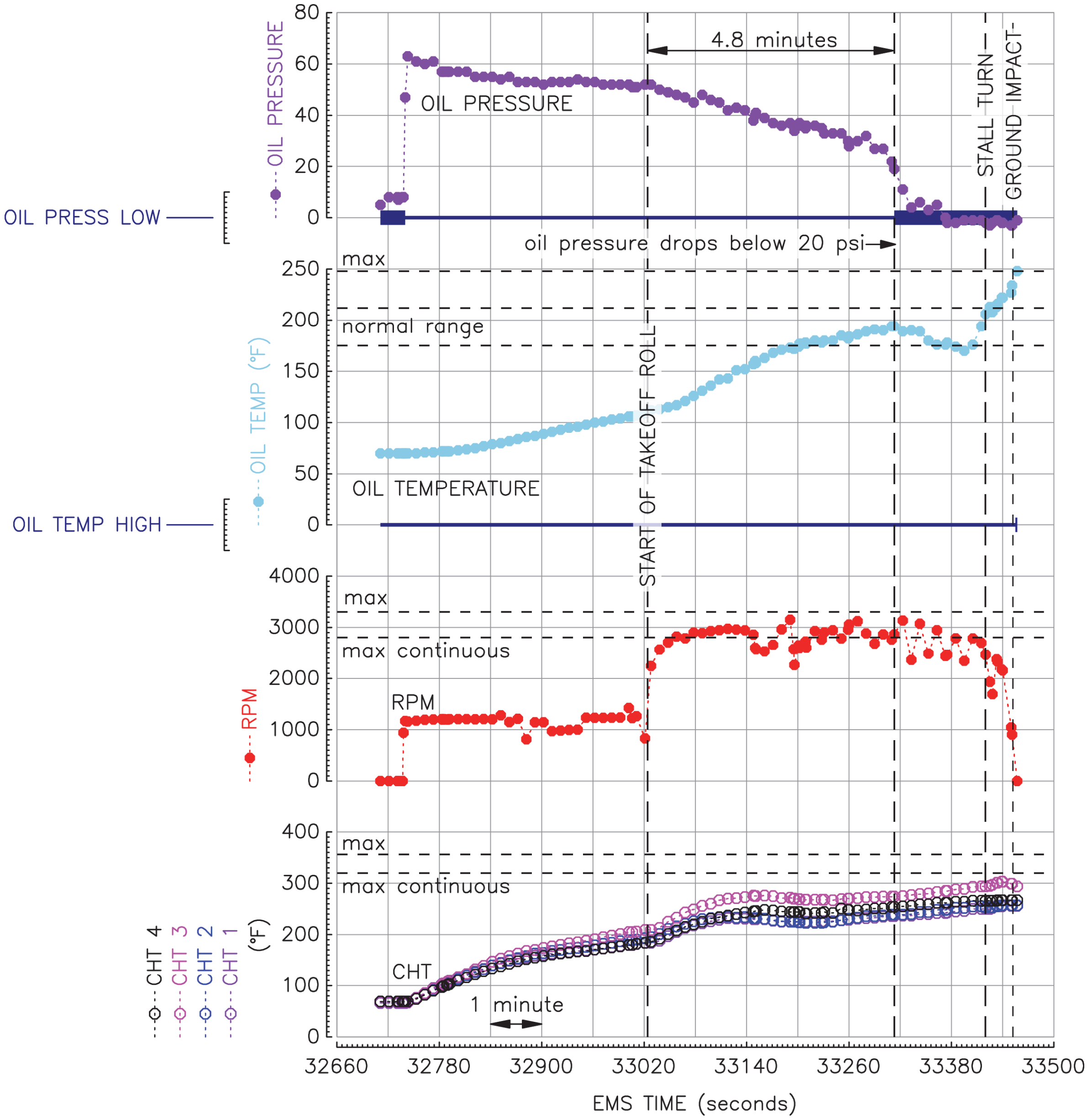

Figure 10

EMS recorded engine data - accident flight

Data from the accident flight was compared with data from a previous flight during which the aircraft flew the same display routine (Figure 11). The engine rpm, oil pressure, oil temperature and CHT profiles (including the hotter running No 3 cylinder) were similar on both flights until five minutes after the start of the takeoff roll, when both oil pressures decreased to below 30 psi. During the earlier display flight there was then a 2.5 minute period in which the oil pressure fluctuated between 16 and 30 psi, causing the low oil pressure warning to activate six times.

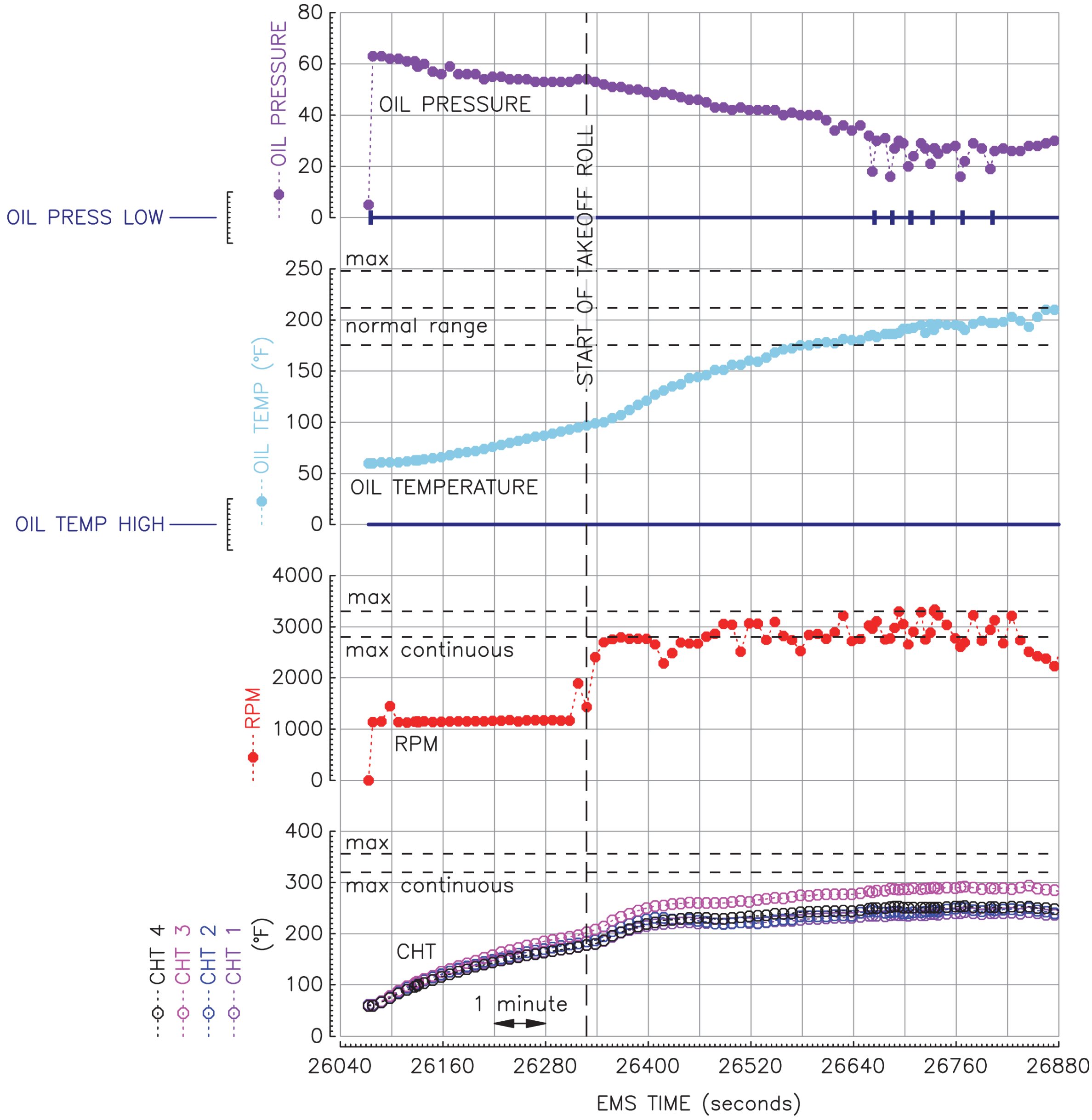

Figure 11

EMS recorded engine data - previous display flight

Engine data from the display flights was also compared with data from the aircraft when it was in cruising flight (Figure 12), during which oil pressure was 43(±2) psi and the oil temperature was stable at 175º F (the lower end of the normal range). The CHTs were also approximately 30º F cooler, with the No 3 cylinder again running hotter by about 20º F.

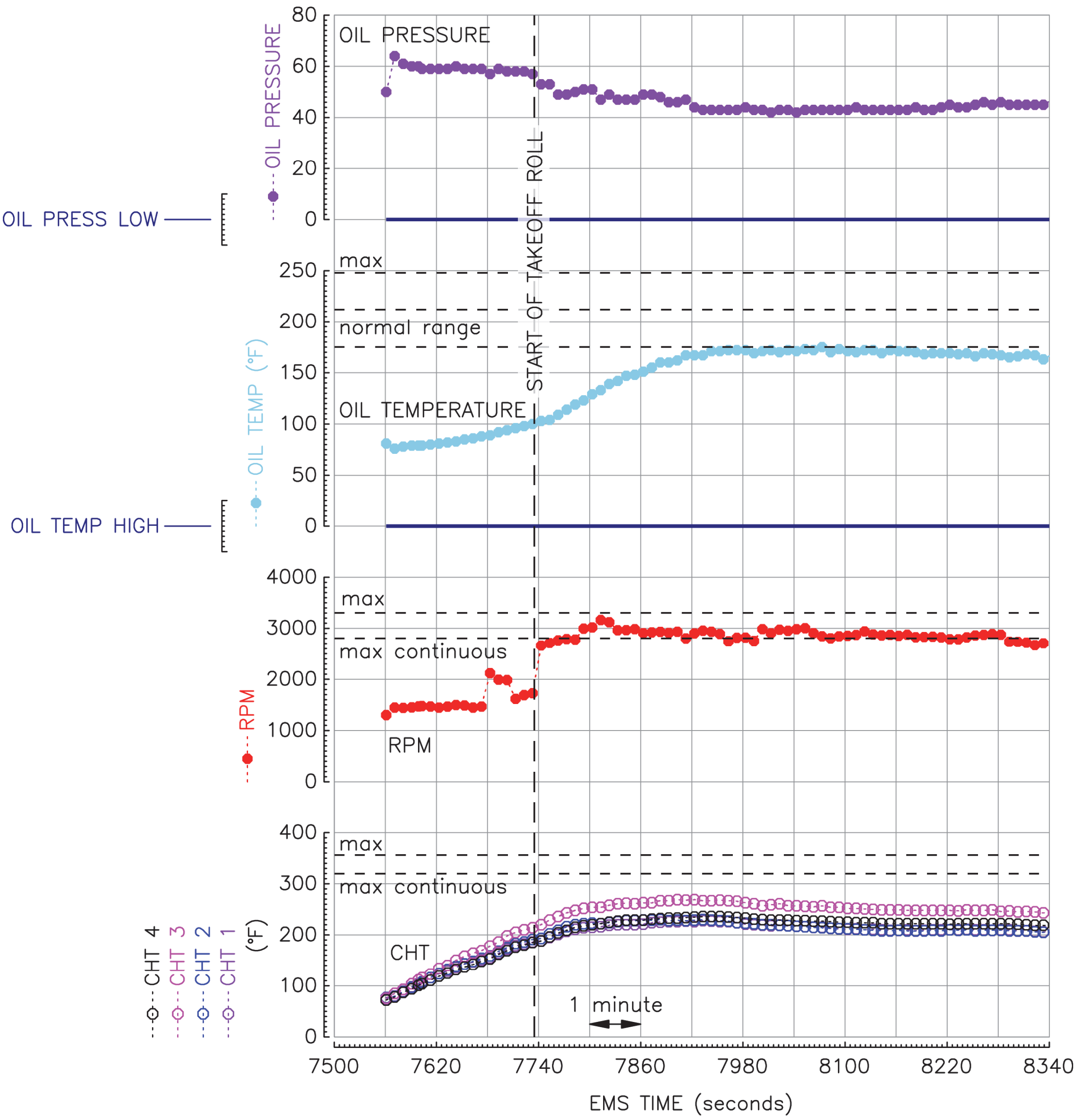

Figure 12

EMS recorded engine data - earlier cruise flight

In total the EMS recorded data for 13 flights. During the 12 flights prior to the accident flight, there were no indications that the engine had operated outside its approved limits.

Analysis

Operational aspects

The pilot of the accident aircraft commented that the relative lack of performance compared with the other aircraft, experienced during the first part of the display, was not unusual and that he had experienced comparable differences, with some difficulties staying in formation, before. Accordingly, this lack of performance alone did not provide an indication that the aircraft's engine was malfunctioning or about to fail.

Formation aerobatic flying involves a high level of concentration, in which the following aircraft pilot's attention must be focussed mainly outside the cockpit. The pilot did not notice the low oil pressure either during the display or the forced landing probably due to the limited internal visual cues and the absence of an audible warning.

When the pilot made the decision to discontinue the display the aircraft was at about 200 ft aal, downwind but close to Runway 18, and with limited opportunities to land ahead or to the left in the obstructed countryside beyond the aerodrome boundary. Having committed to landing on the runway, the pilot climbed initially and turned left to provide manoeuvring distance from the runway. He then flew a tight right turn, attempting to roll out on the runway's extended centreline without overflying the crowd line. However, due to the aircraft's low altitude and a crosswind from the west, he was unable to complete the manoeuvre. The aircraft flew through the runway centreline and struck the grass a few metres to the east of the runway whilst still descending.

The EFIS data indicates that 12 seconds before ground impact, as the aircraft began the turn to the right, the airspeed was approximately 65 kt, which is the speed stated in the flight manual to be flown in the event of '*Emergency landing with a stopped engine*'. During the first half of the turn this airspeed would have reduced as height was maintained. Halfway around the turn, as the bank angle increased and the nose dropped, the aircraft accelerated towards the ground and continued to do so until shortly before impact. However, the recorded speed at approximately 60 ft agl was 46 kt, at which there would have been limited opportunity to reduce the rate of descent, but he was able to level the wings before impact.

Engineering

General

The engineering evidence indicates that the engine operated normally until part way through the flying display when it seized due to a lack of lubrication and cooling.

A comparison of the data downloaded from the EMS with a video of the accident flight showed that the engine stopped approximately 7 minutes after the start of the takeoff run. There were no indications to warn the pilot that there was a problem with the engine, other than the low oil pressure discrete which operated for about 2.5 minutes before the engine stopped. All the other engine parameters were similar to those recorded during a previous display flight. There was no evidence from the previous 12 flights recorded in the EMS that the engine had operated outside its approved limits.

Engine seizure

The engine cylinder heads are mainly cooled by air, and the pistons and cylinders by oil. During an aerobatic flight the engine is often not only operating at a higher power setting, but the airflow into the engine will vary depending on the manoeuvre. While the engine oil system has been designed for aerobatic operations, the manufacturer advised that it might not be able to provide oil at the suction side of the pump during the full range of aerobatic manoeuvres, particularly when the engine experiences negative g. During the previous display flight the oil pressure reduced to 16 psi, which is considerably lower than the minimum of 40 psi seen in the cruise, but just above the minimum allowable operating pressure of 14.5 psi. A reduction in the oil supply might not initially be detected by an increase in the CHT or generate any engine warnings; however, the reduction in oil cooling could result in the pistons overheating, expanding, and with the lack of lubrication on the cylinder walls, starting to ‘grab’. This could damage the pistons and ultimately cause the engine to seize.

While the pilot reported that there was sufficient oil in the engine at the start of the flight, the internal damage to the engine indicated that it had been operating for a short time without adequate oil cooling and lubrication. However, following the accident flight the oil system was assessed as serviceable and there was no evidence that oil could have been lost in flight other than through the exhaust system. Because oil was being injected into the exhaust system to produce smoke during the flying display, a loss of engine oil by this route would not be detected visually from the ground.

The amount of oil in the breather separator tank was not excessive; however, the possibility that one of the breather inlet valves stuck open, allowing crankcase pressure to blow the oil into the exhaust, could not be excluded. It is also possible that the oil leaked past the No 3 cylinder piston.

There was no evidence of cracking on the damaged No 3 cylinder piston; the damage was assessed as consistent with the piston overheating and expanding in the cylinder. It is possible that the damage to this piston accumulated over several flights, with a sudden failure, sufficient to cause the loss of oil, occurring during the accident flight. However, given the level of damage to the piston and cylinder it was not possible to establish if this was the case.

The maintenance history of the engine indicates that the engine had experienced numerous problems following the propeller strike that occurred at 464 engine hours. The No 3 cylinder had been operating at CHT approximately 20º F higher than the other cylinders, which the manufacturer advised was normal and within acceptable limits. It was not possible to determine if the other maintenance issues were coincidental or if they indicated a problem resulting from the propeller strike.

Survivability

The Twister aircraft is unusual among light aircraft in incorporating a cockpit safety cell of Kevlar composite construction. This feature, combined with the reclined seating position, energy absorbing cushions and the absence of sharp protrusions in the area of the head, probably contributed to the survivability of this accident.

Canopy opening

The emergency services reported difficulty in gaining access to the unconscious pilot as they did not know how to open the canopy and were concerned that they would further injure him if they tried to break it.

The canopy of the Silence Twister is not required to conform to the CS-VLA.

Safety actions

Engine

The engine manufacturer advised the AAIB that it would introduce processes to monitor the condition of UL260iSA engines in regular aerobatic use, including:

- Installing additional temperature sensors in the cylinder walls.
- Regularly downloading and reviewing the data from the Dynon EMS-D10.
- The return of the engine to the manufacturer after a number of aerobatic displays for a full strip and examination.

The manufacturer stated that it intended to issue an amendment to the engine manuals recommending that:

- The engine oil level should be between 4 and 4.5 litres prior to the start of an aerobatic display.
- A Teflon based additive should be added to the oil.
- Maintenance activities such as removing cylinder heads and replacing cylinders should be carried out by technicians approved by the manufacturer.

Canopy opening

Following the accident to G-JINX, the LAA amended its Technical Leaflet 2.11 *'Aircraft Placards, Labels and Registration Marks'* to include the following:

> *'When not otherwise obvious, the external and internal latches on cockpit doors and canopies should be clearly identified by labels or markings sufficiently prominent to be seen in an emergency. In the event of an accident, even a few seconds saved by first responders in rescuing the crew may be critical to a positive outcome, especially where there is the threat of fire. Each normal and emergency exit operating control should be red in colour. Suitable placards*

should be near each control and should be designed to clearly indicate its method of operation, especially to a non-aviation person. Where any special procedure must be followed to gain entry, this should be described, for example 'to open canopy in an emergency, reach into cockpit through ventilator aperture and press red button. Canopy hinged on right hand side.'

Following the accident, the owner fixed labels to the outside of his other two Silence Twister aircraft explaining how the canopy is opened from the outside.

EMS audio alert

The aircraft owner stated he would consider enabling the EMS intercom audio alert function.

Conclusion

The engine operated normally until part way through the flying display when it seized due to a lack of lubrication and cooling. The available low oil pressure indications were not sufficient to alert the pilot before the engine seized. The subsequent forced landing resulted in impact sufficient to cause damage to the aircraft and serious injury to the pilot. Emergency responders were delayed by the absence of instructions, visible from outside the cockpit, explaining how the canopy could be opened. However, energy absorbing cushions and the safety cell construction of the cockpit contributed to the pilot's survival.