SERIOUS INCIDENT

Aircraft Type and Registration:	Airbus A320-232, 9H-LOZ	
No & Type of Engines:	2 IAE V2500 turbofan engines	
Year of Manufacture:	2006 (Serial no: 2838)	
Date & Time (UTC):	28 May 2021 at 0825 hrs	
Location:	London Stansted Airport, Essex	
Type of Flight:	Commercial Air Transport (Non-revenue)	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	None	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	30 years	
Commander's Flying Experience:	5,290 hours (of which 5,100 were on type) Last 90 days – 25 hours Last 28 days – 6 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

On a routine short flight, during final approach to land, the No 2 engine reduced to idle and would not respond to any control inputs. The flight crew performed a missed approach and, following the relevant checklist procedure, elected to shut down the engine. They then performed an uneventful single-engine approach and landed safely. The engineering investigation determined that the cause of the engine problem was most likely an inadvertent activation of the overspeed protection valve in the fuel control system. The problem has occurred previously on other V2500 engines and is being addressed through safety actions by the engine and aircraft manufacturers.

History of the flight

The aircraft was scheduled to conduct a preservation flight[1] on 28 May 2021, departing from and returning to Stansted Airport and lasting approximately 45 minutes. The operating crew positioned from Vienna to Stansted as passengers on a commercial flight, arriving in the crew room at Stansted at 0630 hrs. They waited for the morning engineering shift to come on duty at 0700 hrs and the aircraft was handed over to them shortly afterwards. The crew conducted the standard walkaround and pre-departure checks with no abnormal findings. The aircraft departed from Stand 33L at 0803 hrs after a normal engine start and pushback and taxied to line up and hold on Runway 22.

Footnote

[1] These were routine flights conducted every 28 days to maintain serviceability of the aircraft during the pandemic reduced flight schedules.

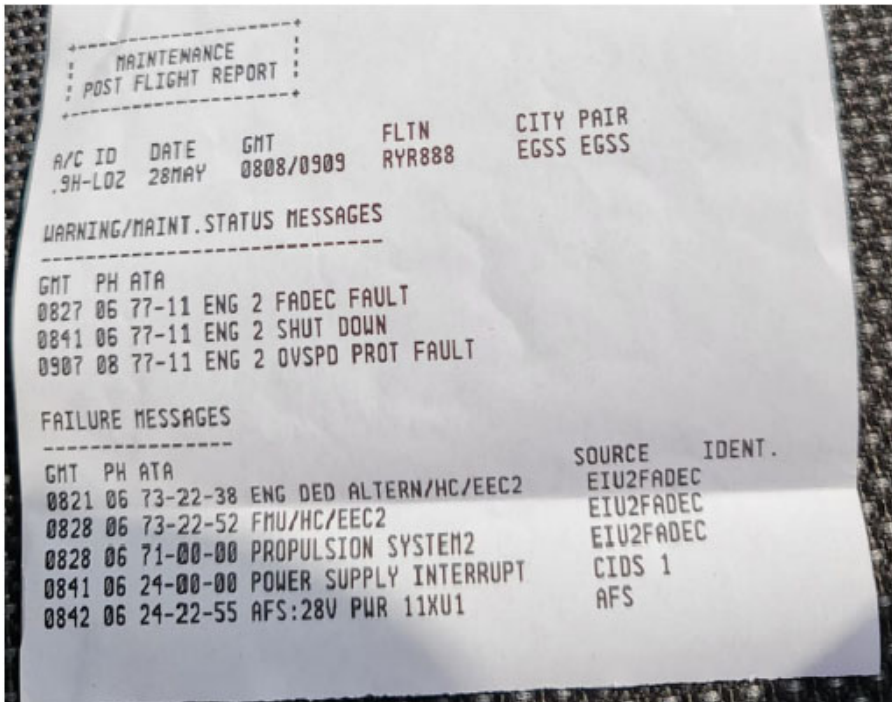
Whilst holding on the runway, the crew were requested by Air Traffic Control (ATC) to consider a new Standard Instrument Departure (SID) route, but they declined this request to avoid the need to re-brief the departure whilst positioned on an active runway. They were given clearance to take off and climb to FL080 following the CLN1E SID, which they completed without issue. They were subsequently given radar vectors to line up for an ILS approach to land back on Runway 22.

During the final approach, at 950 ft radio altitude and with autothrust engaged, an 'ENG 2 FADEC FAULT' appeared on the Electronic Centralised Aircraft Monitor (ECAM). The crew elected to go around and manually flew the standard missed approach profile, before entering a hold to perform troubleshooting of the fault. During this period the No 2 engine remained at idle despite manual throttle increases and the reselection of autothrust. The crew also reported seeing apparently erroneous engine parameter readings relative to the selected throttle position. After entering the hold, the immediate ECAM checklist actions were performed. The crew reported that the engine indications were not showing amber XX, but appeared to be frozen and were still not responding to any throttle inputs. The ECAM checklist directed that in the case of abnormal engine parameters the engine should be shut down. The crew consulted the Flight Crew Operating Manual (FCOM) for further guidance, before starting the Auxiliary Power Unit (APU) and shutting down the No 2 engine.

The crew declared a MAYDAY and selected squawk 7700. They then briefed for a return to Runway 22 at Stansted. After completing all the necessary single-engine operation checklists and landing performance calculations, they requested radar vectors for a normal ILS approach to Runway 22. Following an uneventful approach and landing, the aircraft vacated the runway and the crew confirmed with the Airport Fire and Rescue Service Commander that the failed engine appeared normal. During the landing rollout as the aircraft airspeed dropped below 70 kts an 'ENG 2 OVSPD PROT FAULT' warning was triggered but this was not displayed on the ECAM. The aircraft was then taxied to Maintenance Hangar 10 at Stansted and shut down in accordance with the relevant checklists.

Initial engineering investigation

The post-flight report was downloaded from the aircraft (Figure 1). The Digital Flight Data Recorder (DFDR) was removed and downloaded, and the data provided to the aircraft manufacturer for further investigation. The post-flight report indicated that additional failure messages had occurred during the flight which did not have an associated ECAM warning. The first was 'ENG DED ALTERN/HC/EEC2', which indicated a failure of the Engine 2 Dedicated Alternator (EDA) or the electrical harness between the alternator and the Electronic Engine Control (EEC) unit. Additionally, 'FMU/HC/EEC2' and 'PROPULSION SYSTEM 2' faults were also recorded. The operator carried out Task 73-22-00-810-834-B *'Failure of the engine dedicated alternator stator on engine 2'* from the aircraft Troubleshooting Manual (TSM) and the EEC, EDA and the Fuel Metering Unit (FMU) from the No 2 engine were removed and sent for further investigation.



MAINTENANCE
POST FLIGHT REPORT

A/C ID	DATE	GMT	FLTN	CITY PAIR
.9H-LOZ	28MAY	0808/0909	RYR888	EGSS EGSS

WARNING/MAINT.STATUS MESSAGES

GMT	PH	ATA	
0827	06	77-11	ENG 2 FADEC FAULT
0841	06	77-11	ENG 2 SHUT DOWN
0907	08	77-11	ENG 2 OVSPD PROT FAULT

FAILURE MESSAGES

GMT	PH	ATA		SOURCE	IDENT.
0821	06	73-22-38	ENG DED ALTERN/HC/EEC2	EIU2FADEC	
0828	06	73-22-52	FMU/HC/EEC2	EIU2FADEC	
0828	06	71-00-00	PROPULSION SYSTEM2	EIU2FADEC	
0841	06	24-00-00	POWER SUPPLY INTERRUPT	CIDS 1	
0842	06	24-22-55	AFS:28V PWR 11XU1	AFS	

Figure 1

Post-flight Report

Related maintenance events prior to the incident flight

On 23 May 2021 a water wash of both engines on the aircraft had been carried out in accordance with the Aircraft Maintenance Manual task 72-00-00-100-010-A. During the required engine runs following this activity an 'ENG 2 OVSPD PROT FAULT' had been triggered. In response the operator conducted two tasks from the aircraft troubleshooting manual, which were *'loss of the N2 signal on engine 2'* and *'loss of the N2 overspeed protection on engine 2'.* The EEC, FMU and EDA electrical harnesses were inspected on the No 2 engine and the engine 2 EEC A and B channels were tested. No faults were identified by these checks and the aircraft was released back into service.

Recorded information

The aircraft manufacturer analysed the recorded flight data for the incident flight and produced a flight track which is shown in Figure 2. To assist in understanding the different phases of the flight the diagram has been annotated as follows:

- Arrow 1 – shows the initial takeoff from Stansted.
- Arrow 2 – shows the departure and climb following the SID.
- Arrow 3 – shows the first approach to land on Runway 22, with the start of the engine fault shown by the yellow pin.
- Arrow 4 – shows the go-around and missed approach route to the hold, with the engine shutdown point indicated by the yellow pin during the second circuit of the holding pattern.

- Arrow 5 – shows the re-join of the circuit at Stansted with the No 2 engine shut down.
- Arrow 6 – shows the single engine final approach and landing on Runway 22.

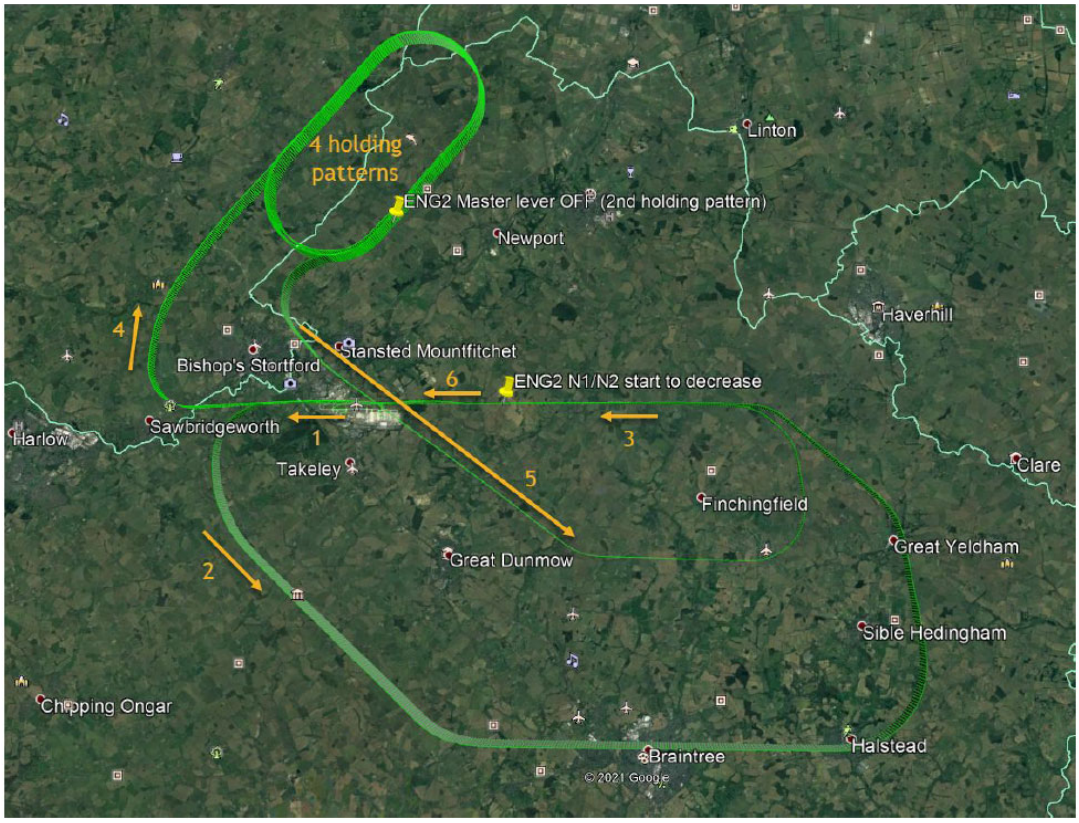


Figure 2

Recorded data showing the incident flight track

An overview of the relevant recorded data parameters for the incident flight, produced by the aircraft manufacturer, is shown in Figure 3. This highlights the section where the No 2 engine problem occurred. From 08:27:46 hrs the EEC commanded EPR target rapidly increased on both engines to maintain the selected aircraft autopilot airspeed. Whilst the EPR increased to match the EEC demand on engine No 1, the No 2 engine EPR began to decrease instead. The ECAM FADEC fault warning was triggered at 08:27:53 hrs and the crew reported that the engine parameters remained as figures rather than switching to amber XX. The actual engine No 2 EPR then remained at a constant value until the engine was shut down.

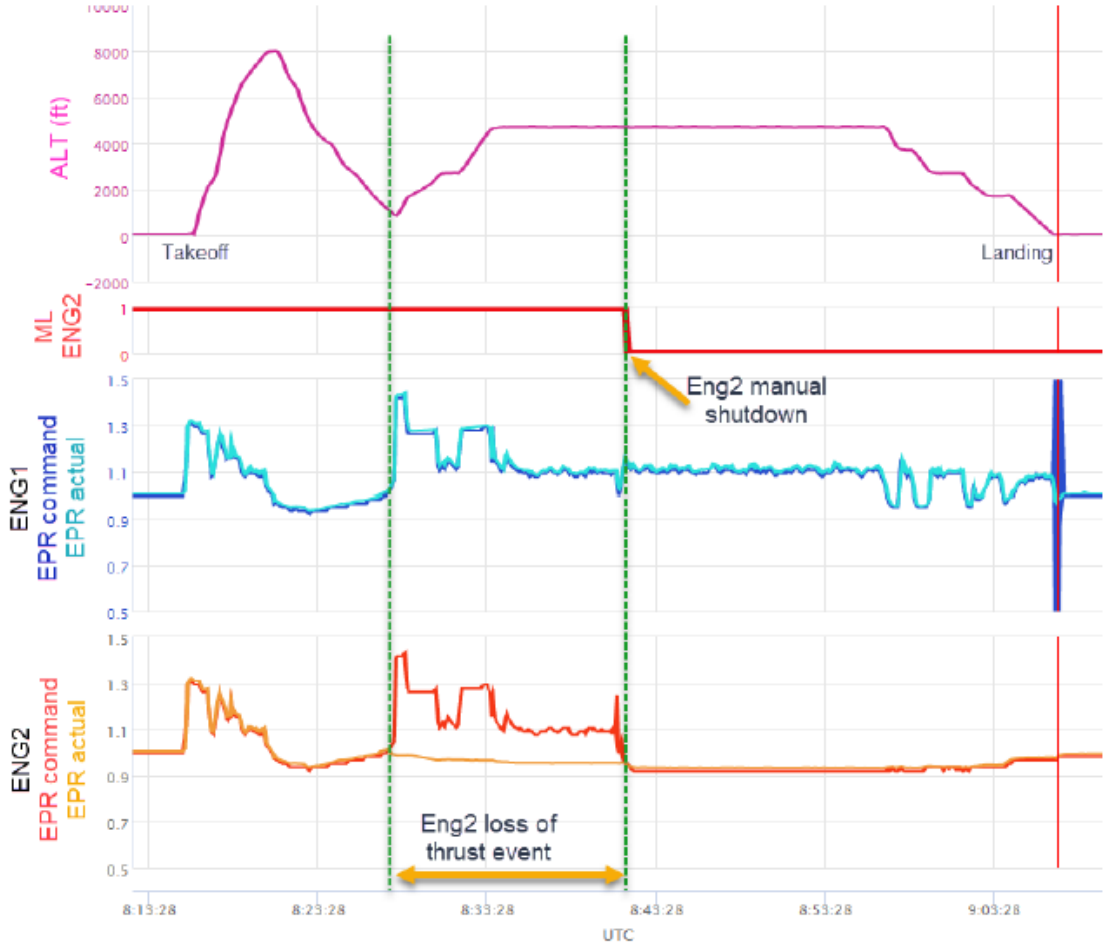


Figure 3

Relevant recorded data parameters for the incident flight

Aircraft information

The aircraft was fitted with two IAE V2527-A5 engines, which are Full Authority Digital Electronic Control (FADEC) equipped. The FADEC system consists of a dual-channel EEC and the associated components and sensors to adjust and monitor the engine thrust and rotational speed. The main engine parameters are the Engine Pressure Ratio[2] (EPR) which indicates the thrust produced by the engine, N1 which is the speed of rotation of the low-pressure spool[3] and the Exhaust Gas Temperature (EGT), which is one of the normal limiting parameters for the engine. In normal mode the EEC computes the EPR figure required based on the throttle position or Flight Management Guidance Computer (FMGC) input, if autothrust is engaged. It then controls the fuel flow to the combustion chamber spray nozzles using the FMU, to achieve the target EPR. If a fault results in the EPR figure not being available, the control system reverts to reversionary mode and uses N1 to control the engine. N2 is the speed of rotation of the high-pressure spool.

Footnote

[2] This is a ratio of the intake air pressure and the exhaust gas pressure, measured by sensors in the engine intake and low-pressure turbine exhaust.

[3] The term spool refers to the entire compressor stages and turbine stages connected by a shaft.

The FMU has three mechanical control features, these are:

- The Fuel Metering Valve (FMV) which under normal operation modulates to deliver a metered fuel flow to the fuel nozzles based on the EEC command.
- An engine overspeed protection valve which works in series with the FMV to reduce the fuel flow to the spray nozzles if an overspeed of either the low-pressure or high-pressure spool is sensed by the EEC.
- A Pressure Rising and Shut-off Valve (PRSOV) which is the main open/shut valve that controls fuel to the engine to facilitate starting and stopping of the engine.

The FADEC system prevents an exceedance of the N1 or N2 spool by control logic which acts directly on the fuel flow commanded by the EEC. When triggered, the fuel flow is reduced but not completely shut off, with the residual fuel flow maintaining the engine at a power setting slightly below flight idle. This fuel flow is fixed and does not respond to throttle position inputs. The overspeed protection valve which achieves this is operated by a dual channel servo valve, commanded by either channel of the EEC. The valve is hydraulically latched once engaged and can only be reset by shutting down the engine.

The EDA is a dedicated alternator fitted to and driven by the engine main gearbox to provide a dedicated Direct Current (DC) electrical power supply to the EEC, independent of the aircraft electrical systems. The EDA also supplies an N2 speed signal to the EEC and cockpit indication. During engine start the EEC receives a 28V DC supply from the aircraft until the EDA takes over at approximately 10% N2. In the event of an EDA failure the EEC will switch back to the aircraft DC supply.

Operating procedures

An 'ENG 2 FADEC FAULT' warning on the ECAM indicates that both A and B channels of the indicated engine EEC have been lost. In many cases this results in the complete loss of the indicated engine parameters, and the figures are replaced by an amber XX indication. When this occurs the engine status can still be checked by referring to the engine's associated indicated parameters such as hydraulic, electric, and pneumatic bleed systems. If abnormal engine behaviour is identified the engine must be shut down using the master engine control lever. The relevant FCOM checklist is shown in Figure 4.

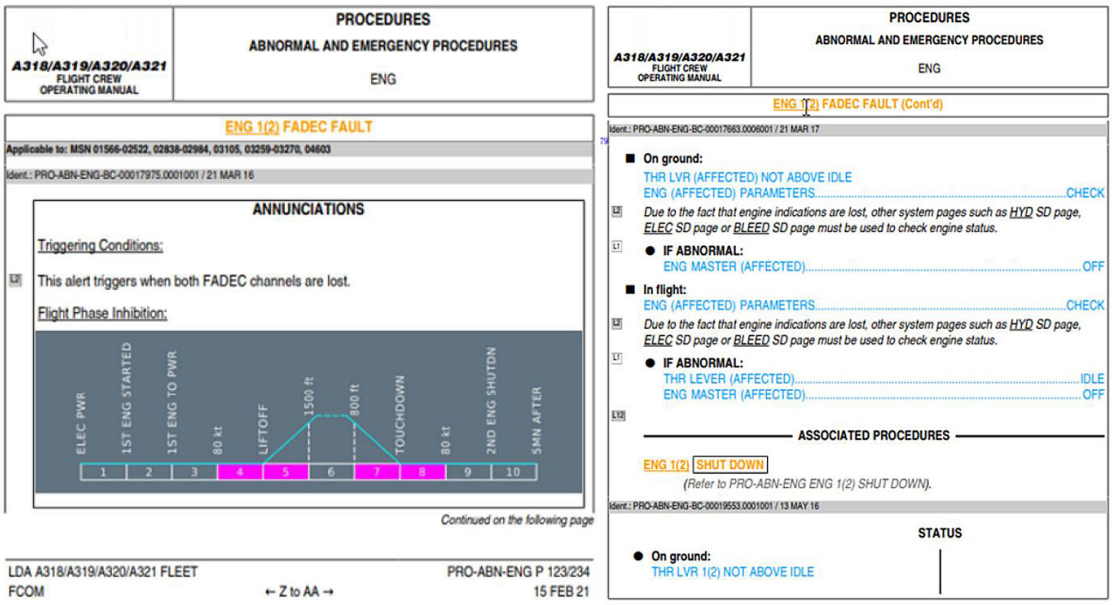


Figure 4

FCOM procedure for ENG 1(2) FADEC FAULT warning

Component investigation findings

EEC

The overhaul report for the removed EEC identified that some contamination was found on the pressure ports but stated that this was not linked to the issue reported on the incident flight.

EDA

The overhaul report confirmed that the component failed on test due to an insulation failure. It stated that this could cause an intermittent EEC electrical failure leading to temporary erroneous computations by the EEC. It is possible that the loss of or erroneous behaviour of the N2 signal can cause a false activation of the overspeed protection within the EEC, but this would have been recorded as a separate fault on the post-flight report and reflected in the N2 parameter values in the flight data. As these indicators were not present, it was ruled out as a possible cause for this incident.

FMU

The overhaul report identified the presence of internal fuel leaks around all three of the mechanical control valves within the FMU, with fuel also present in the electrical wiring cavity. These are known issues on the engine and are subject to ongoing product improvement processes by the engine manufacturer.

Previous similar events

Uncommanded (by the EEC) closure of the overspeed protection valve within the FMU has been experienced in previous similar events on other V2500 engines in service. These events have resulted in either a FADEC, engine stall[4], or engine overspeed protection fault warning being triggered. In all cases the engine ran down to idle and neither physical movement of the throttle nor autothrust commands from the FMGC had any effect on the engine.

Analysis

The manufacturer's assessment of the failure messages seen on the post-flight report and the ECAM warning was that they were consistent with the reduction in EPR caused by an uncommanded activation of the overspeed protection valve in the FMU. This reduced the fuel flow to the engine to a fixed level which was just below flight idle. The flight data values recorded for N1 and N2 immediately prior to this were normal and confirmed that no actual overspeed had occurred, which would have resulted in the valve correctly operating. Once activated, the fixed flow rate through the overspeed protection valve cannot be varied by any input from the throttle or the FMGC. As such, the apparently frozen parameters reported by the flight crew were an accurate indication of the engine status.

The other ancillary engine indications and associated systems' operating parameters recorded by the DFDR were all consistent with this. The valve remained hydraulically latched while the engine was operating but would have reset after the engine was shut down. The final overspeed protection fault warning seen on the post-flight report is intentionally inhibited by the system until after touchdown and the aircraft airspeed has reduced below 80 kt, which is why it appeared to occur after the engine had been shut down. The previous in-service events where the overspeed protection valve had operated without being commanded by the EEC, were very similar to this incident involving 9H-LOZ. It was not possible to confirm a definitive root cause for the activation of the overspeed protection valve from the evidence recovered by the investigation. However, these events are all the subject of ongoing continued airworthiness activities by the engine and aircraft manufacturers.

Safety actions

It has been reported that the engine manufacturer has conducted investigations at component and system level to understand the cause of the inadvertent overspeed protection valve activations. Definitive identification of the root cause has not been possible, but several factors have been identified as possible contributors. These will be addressed as product improvement changes to the FMU and are targeted to be available in Q3 2022. The aircraft manufacturer reported that progress on these issues is regularly communicated to operators of the engine during customer meetings, in which both the aircraft and engine manufacturers participate.

Footnote

[4] No evidence of the engine experiencing an actual stall or surge was reported.

At the request of the operator of 9H-LOZ, the aircraft manufacturer also agreed to review the wording of the FCOM procedure for an 'ENG 1/2 FADEC FAULT' warning, to advise crews that the parameters will not always revert to 'XX' in the event of a problem occurring and may appear as frozen or abnormal values.