SERIOUS INCIDENT

Aircraft Type and Registration:	Airbus A319-131, G-EUPO
No & Type of Engines:	2 International Aero Engine V2522-A5 turbofan engines
Year of Manufacture:	2000 (Serial No: 1279)
Date & Time (UTC):	17 December 2010 at 1320 hrs
Location:	On approach to London Heathrow
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 122
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	16,080 hours (of which 1,221 were on type) Last 90 days - 208 hours Last 28 days - 58 hours
Information Source:	Field Investigation

Synopsis

On approach to London Heathrow Airport, in IMC and icing conditions, there was a loss of communication between the Probe Heat Computers (PHC) and the Centralised Fault Display System (CFDS). The associated Electronic Centralized Aircraft Monitoring (ECAM) actions required the crew to select ADR3 as the data source for the commander's instruments.

Later, on final approach to Runway 27L, the aircraft suffered a loss of displayed airspeed information on both the commander's and the standby flight instruments. The crew carried out a go-around using the *'Unreliable Speed Indication'* procedure from the Quick Reference Handbook (QRH).

The investigation concluded that the loss of displayed airspeed information resulted from a combination of:

- a loss of communication between the Probe Heat Computers (PHC) and the Centralised Fault Display System (CFDS),
- icing of the standby pitot probe resulting in the loss of indicated airspeed displayed on the commander's and standby instruments.

One Safety Recommendation was made.

History of the flight

The incident occurred during a flight from Geneva to London Heathrow Airport. Prior to despatch there were two outstanding Minimum Equipment List (MEL) items, the forward cargo hold was unusable and the APU was unserviceable. Prior to starting the engines at Geneva a VENT AVNCS SYS FAULT[1] caution message appeared on the Electronic Centralized Aircraft Monitoring (ECAM) screen, which was cleared by resetting the circuit breakers in accordance with the Quick Reference Handbook (QRH) procedure. During the initial part of the climb a CAB PR SYS 1 FAULT[2] caution appeared on the ECAM screen. The crew discussed the possible consequence of a subsequent cabin system 2 pressure failure, and continued the flight to Heathrow.

The aircraft was being flown by the co-pilot with the autopilot and autothrust engaged. During the descent the flight was routed to the 'BIG' VOR and then was given radar vectors towards the final approach for Runway 27L. The route from BIG was conducted in IMC and icing conditions. Engine anti-ice was selected ON, and wing ice was selected ON when accretions of ice were seen by the flight crew on the visual ice indicator. During this stage of flight the ANTI ICE CAPT R STAT[3] and ANTI ICE CAPT TAT[4] caution messages displayed on the ECAM. The crew carried out the ECAM actions which were to set the Air Data selector switch to the CAPT 3 position and select the Probe Heat to ON. The standby (stby) ASI was cross-checked with the speed indications on the Primary Flying Displays (PFD) and, as they were in agreement, the crew continued with the approach[5].

Footnotes

[1] Fault in the ventilation system in the avionics bay.
[2] Fault on one of the two cabin pressurisation systems.
[3] Fault on the anti-icing on the Captain's right static probe.
[4] Fault on the anti-icing on the Captain's Total Air Temperature probe.
[5] In this configuration the PFD and standby indications are from the same source, ADIRU 3.

Seven minutes later, with the aircraft descending through 7,000 ft amsl, an ANTI ICE STBY R STAT[6] caution message appeared on the ECAM. Because of the number of messages received relating to anti-icing, the crew decided, as a precaution, to review the QRH procedure for unreliable speed.

On final approach, just as the co-pilot (now acting as PNF) had started to review the procedure, the commander's indicated airspeed showed a reduction to VLS (lowest selectable speed). Up to this point the target airspeed on the PFD had been generated by the Flight Management and Guidance System (FMGS), but in response the commander selected speed on the Flight Control Unit (FCU) and increased the target speed in an attempt to increase airspeed. However, the indicated airspeed continued to decay rapidly to around 50 - 60 KIAS and the stby ASI indication simultaneously fell to 0 KIAS.

The commander announced "UNRELIABLE AIRSPEED" and called for a go-around. The aircraft was in IMC at 800 ft aal and configured for landing with flap FULL when the co-pilot initiated the go-around. He disconnected the autopilot and autothrust, selected TOGA thrust and flew the target pitch attitude of 15° nose up. (Figure 5). The flaps remained at full in accordance with the memory items for the QRH UNRELIABLE SPEED INDIC/ADR CHECK procedure, retraction of the landing gear was not completed until the aircraft had climbed to 4,000 ft. The commander declared a MAYDAY to ATC and advised that the aircraft was going around and would climb straight ahead.

The aircraft climbed on the runway heading, until safely above the Minimum Safe Altitude (MSA), and

Footnote

[6] Fault on the anti-icing on the right standby static probe.

was then levelled at 4,000 ft amsl, using the pitch and power settings obtained from the QRH UNRELIABLE SPEED INDIC/ADR CHECK procedure. The aircraft was given a radar vector to turn onto a northerly heading and climbed to 5,000 ft, which took it clear of the icing conditions. The crew then continued with the QRH procedure, diagnosed the failure by cross-checking the displayed airspeed indications and altitude against the GPS data, and determined that ADR 2 was the only source of reliable air data.[7] In accordance with the QRH actions for one reliable ADR, the crew turned ADR 1 and 3 OFF. The aircraft was now in Alternate Law and the Flight Path Vector function was used to aid the flying of the aircraft.

A squawk of 7700 was issued by ATC. The crew reviewed the weather conditions, and their options, and decided to divert to Luton Airport where the weather was better and the aircraft could remain clear of icing conditions. The landing was made on Runway 26 in Direct Law with the flaps set at configuration 3. After the aircraft was brought to a halt on the runway, one of the inoperative systems messages displayed on the ECAM status page was NW STRG[8]. The commander requested that the aircraft be towed to a stand because of the possible difficulty of manoeuvring without nosewheel steering on a surface which might be icy.

Meteorological information

The weather at London Heathrow Airport was reported as a surface wind from 290° at 11 kt, scattered cloud at 600 ft, broken cloud at 2,400 ft, heavy snow showers, visibility of 900 m, temperature -1°C, dew point - 4°C, and QNH of 997 HPa.

The crew reported heavy cloud cover and sub-zero temperatures along much of the route between BIG and Heathrow Airport. They observed accumulations of rime ice and clear ice on the external visual ice indicator at various times during the flight.

Post-Flight Report

The Post-Flight Report (PFR) for the incident flight provided the following ECAM warning and failure messages shown in Tables 1 and 2.

System information

Electronic Instrument System

The Electronic Instrument System (EIS) includes the Primary Flying Display (PFD) and Navigation Display (ND), and the Electronic Centralized Aircraft Monitoring (ECAM) functions.

The ECAM uses aircraft system data which has been processed by the System Data Acquisition Concentrators (SDAC), Flight Warning Computers (FWC) and Display Management Computers (DMC). This data is then presented to the flight crew on the Engine/Warning Display (E/WD) and System Display (SD). The E/WD displays the engine and fuel parameters, the check list and warning messages, and certain information relevant to system operation. The SD displays synoptics giving the configuration and status of various aircraft systems.

Centralised Fault Display System

The Centralised Fault Display System (CFDS) provides a central maintenance aid which allows maintenance information to be extracted as well as system, and sub-system, BITE tests to be initiated from the cockpit.

Footnotes

[7] The Air Data selector switch was selected to the CAPT 3 position thus the ADR1 data was not displayed.

[8] The NW STRG message appeared on the ECAM as a result of ADIRU 1 and 3 having been turned OFF. Above 260 kt ADIRU 1 and 3 close the Green hydraulic safety valve which powers the nose wheel steering. With ADIRU 1 and 3 turned OFF the hydraulic safety valve would have remained closed and hydraulic power would not have been available for nose wheel steering.

ECAM Warning Messages			
Time	**Flight Phase**	**Message**	
11:26	2[1]	VENT AVNCS SYS FAULT	
11:45	5[2]	CAB PR SYS1 FAULT	
12:55	6[3]	ANTI ICE CAPT TAT	
12:55	6	ANTI ICE CAPT R STAT	
13:02	6	ANTI ICE STBY R STAT	
13:08	6	MAINTENANCE STATUS F/CTL	
13:09	6	NAV IAS DISCREPANCY	
13:09	6	AUTO FLT A/THR OFF	
13:19	6	F/CTL ALTN LAW	
13:19	6	NAV ADR 1 FAULT	
13:19	6	AUTO FLT RUD TRV LIM1	
13:19	6	SFCS	
13;19	6	NAV ADR 1 – 3 FAULT	
13:33	6	F/CTL DIRECT LAW	
13:33	8[4]	F/CTL ALTN LAW	

Table 1

Failure Messages				
Time	**Flight Phase**	**Message**	**Source**	**Ident**
11:23	2	MCDU3(3CA3)/ATSU1(1TX1)	ACARS MU	
11:45	5	PRESS CONTR 1	CPC 1	
12:55	6	NO PHC 1 DATA	CFDS	
13:01	6	NO PHC 3 DATA	CFDS	
13:08	6	AIR3	EFCS 2	EFCS 1 / AFS
13:09	7[5]	SEC 3 OR BUS 2 FROM ADR 2	EFCS 2	EFCS 1
13:10	6	DMC 1: NO ADC 3 DATA	EIS 1	EIS 3
13:15	6	NO ADR 1 DATA	CFDS	Various systems
13:19	6	DMC 1: NO FAC 1 DATA	EIS 1	EIS 3
13:19	6	ATC1 (1SHID) / TCAS (1SG)	TCAS	
13:19	6	DMC 2: NO TCAS DATA	EIS 2	EIS 1 EIS 3
13:24	6	NO DATA FROM ADIRS	TEMP CTL	
13:25	6	DMC 3: NO ADC1 DATA	EIS 3	EIS 1

Table 2

Table 1 Footnotes

[1] Flight phase 2 - On the ground, first engine to achieve takeoff power.
[2] Flight phase 5 - Takeoff and climb to 1,500 ft.
[3] Flight phase 6 - End of phase 5 until aircraft descends below 800 ft.
[4] Flight phase 8 - Touchdown to 80 ft.

Table 2 Footnotes

[5] Flight phase 7 - Below 800 ft to touchdown.

It comprises a Centralized Fault Display Interface Unit (CFDIU), which receives data from other aircraft systems BITE. The CFDIU is accessed from two Multipurpose Control and Display Units (MCDU) located in the cockpit, which can be used to initiate tests and to call up other reports such as the Post-Flight Report (PFR).

Air Data and Inertial Reference System

The Air Data and Inertial Reference System (ADIRS) supplies temperature, anemometric, barometric and inertial parameters to the PFD and ND as well as various other systems. The ADIRS includes three identical Air Data and Inertial Reference Units (ADIRU) each of which has two parts: the Air Data Reference (ADR) and the Inertial Reference (IR). The ADR supplies barometric altitude, airspeed, mach, angle of attack, temperature and overspeed warnings. An ADIRS panel, located in the cockpit, allows the crew to select the mode for each ADIRU and provides information on the status of the IR and ADR systems. The normal procedure is for all three ADIRU to be selected on during flight with ADIRU 1 providing information to the Captain's[9] (Capt) instruments, ADIRU 2 providing information to the First Officer's[10] (F/O) instruments. In the event of a failure of ADIRU 1 or 2, ADIRU 3 can be selected to provide information to either the Capt or the F/O instruments. In normal operation, all three ADIRU constantly provide air data to a number of systems including flight guidance, autoflight and autothrust.

The air data is provided to the ADIRU from three pitot probes, six static pressure probes, three Angle of Attack (AOA) sensors and two Total Air Temperature (TAT) probes (Figure 1). The data from the AOA and TAT probes is provided directly to the ADIRU as an electrical signal, whereas air pressure from the pitot and static probes is first converted at an Air Data Module (ADM) into an electrical signal. Air pressure is provided directly to the stby airspeed indicator and altimeter from static and pitot probes that are also linked by two ADMs to ADIRU 3. The pitot head probes, static ports, AOA probes and TAT probes are electrically heated by three independent Probe Heat Computers (PHC) that automatically control and monitor the electrical power to the Capt, F/O and stby probes.

Probe heat computers

The three PHC monitor and control the electrical power to the heating elements in the probes, ports and AOA sensors. If the electrical current consumption is outside limits, ECAM warnings are generated by the FWS, using discrete signals sent by the PHC through the ADIRU (Figure 2). BITE messages are generated directly by the PHC and recorded in NVM as well as being sent to the CFDIU on two ARINC channels (data buses). In the event that the data communication between the PHC and CFDIU is lost, ECAM warnings will still be displayed if the discrete outputs from the PHC are still available, but the associated BITE fault message will not be recorded by the CFDIU.

The NVM in the PHC, in which the BITE messages are stored, is cleared during each ground/flight transition as computed by the Landing Gear Control and Interface Unit (LGCIU). Opening the Circuit Breaker (CB) on the power supply to at least one of the two LGCIU will also clear the PHC BITE messages, even if the aircraft has not flown.

Flight control laws

The fly-by wire flying control system can operate in Normal Law, Alternate Law or Direct Law. In Normal Law the system automatically protects the aircraft throughout the flight envelope for load factor limitation,

Footnotes

[9] In Airbus documentation the Captain refers to the left side.
[10] In Airbus documentation the First Officer refers to the right side.

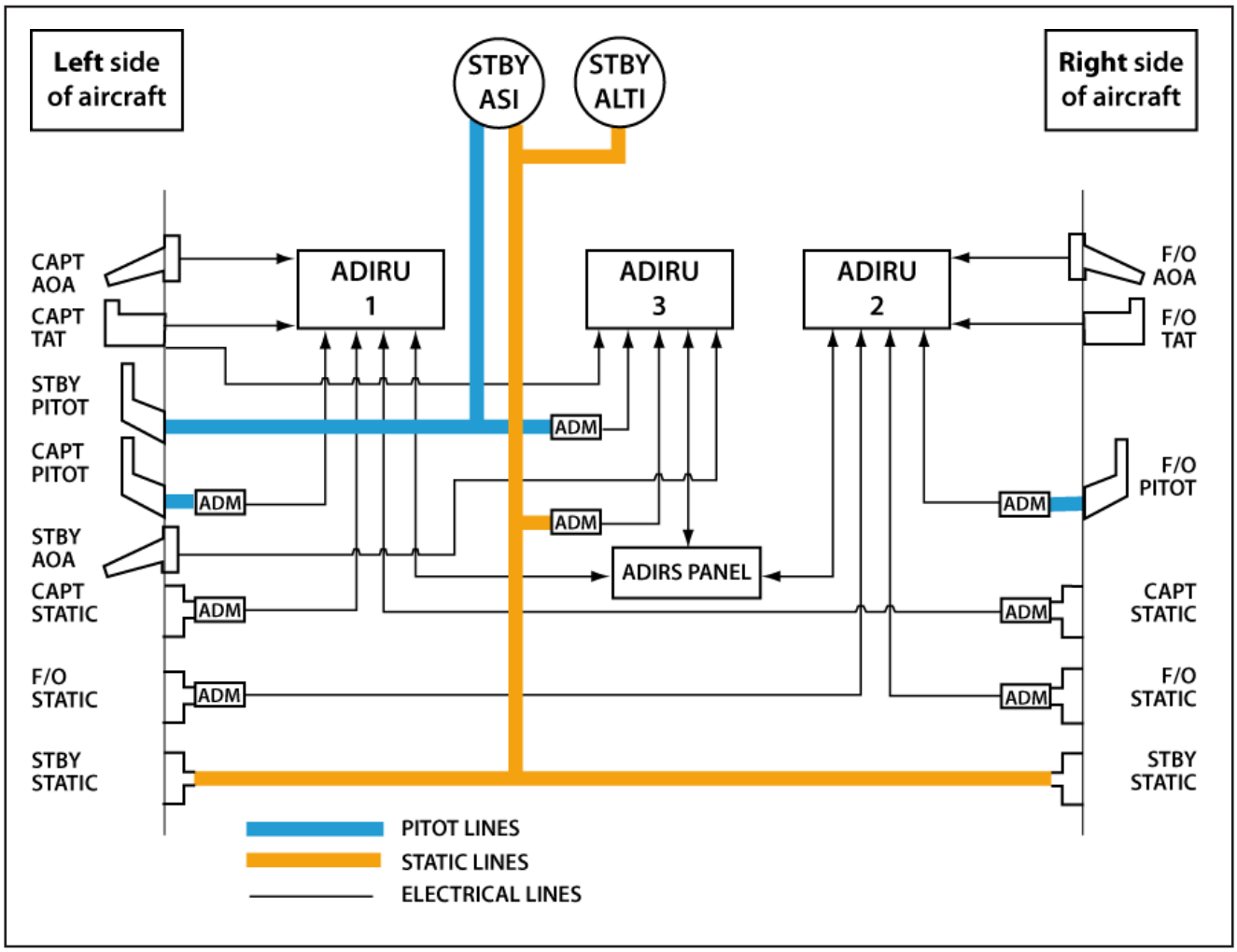


Figure 1

Air data system

pitch attitude, high AOA, high speed and bank angle protection. In the event of a loss of inputs, such as air data, the system will degrade into Alternate Law where some of the protection is either lost or altered. When the landing gear is selected DOWN in Alternate Law, the aircraft degrades further to Direct Law; in Direct Law all the protections are lost.

Cabin pressure control and monitoring system

The Cabin Pressure Control and Monitoring System (CPCS) controls the pressure within the fuselage either automatically or manually by the flight crew. The system has two, independent and automatic systems that contain a Cabin Pressure Controller (CPC), which controls the cabin pressure through an outflow valve. With the CPCS in automatic mode, the FMGS provides the destination QNH and the landing elevation to the CPC, while the ADIRU provides the pressure altitude. During any flight, one CPC is in active mode and the other is in standby mode. When CPC 1 is active it uses data from the ADIRS in the priority ADIRU 1, ADIRU 2 and ADIRU 3. If the active CPC detects a fault it switches to standby and the remaining CPC takes over active control. A warning is then sent to the ECAM EW/D via the SDAC and FWC. The BITE message is retained in the CPC and can be viewed on

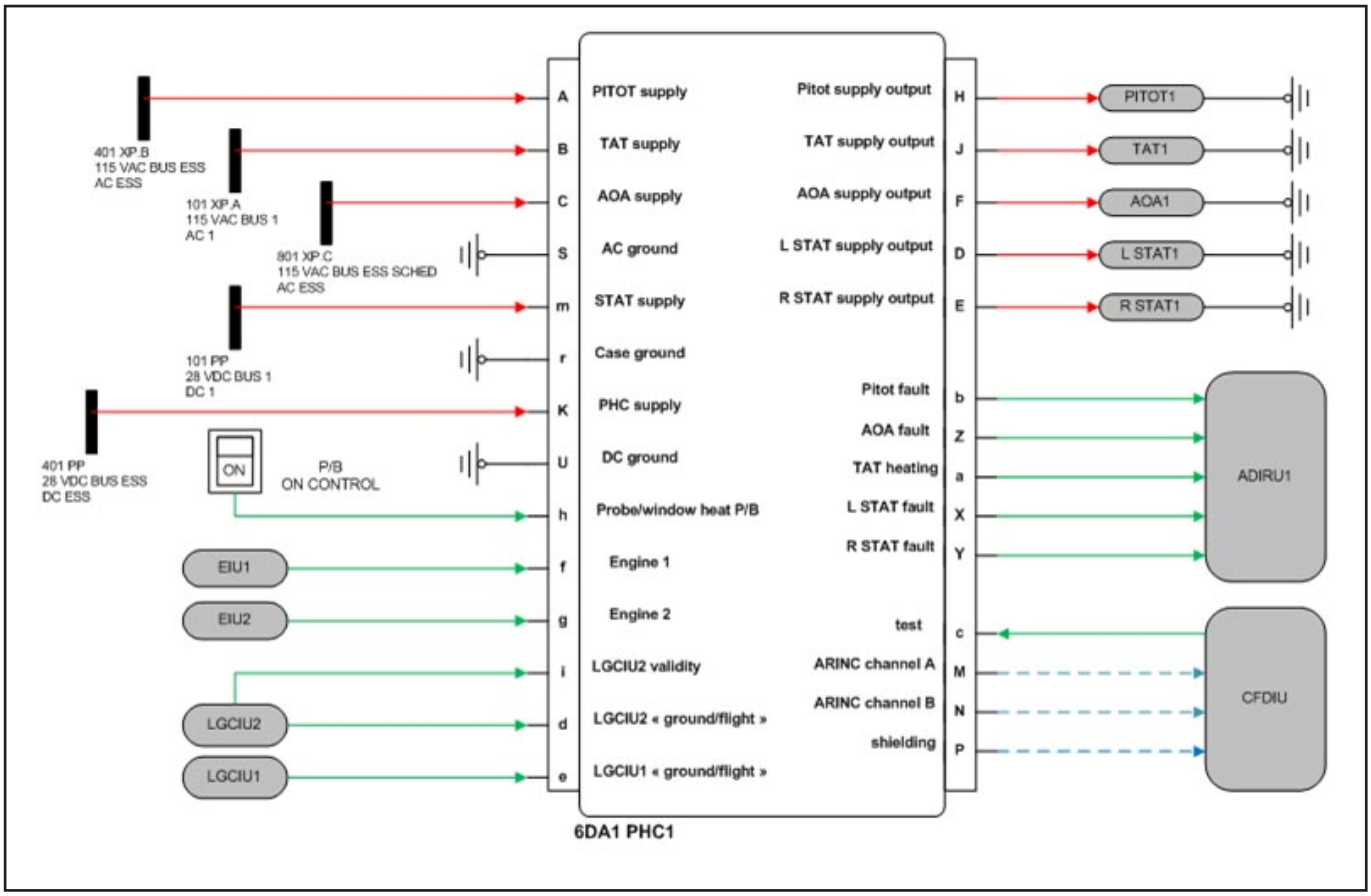


Figure 2

PHC, input and output signals

the MCDU via the CFDIU. The failure message PRESS CONTR 1 means that that there is a fault in CPC 1.

Flight recorders

Introduction

The aircraft was equipped with a 25-hour duration Digital Flight Data Recorder (DFDR), a 120-minute Cockpit Voice Recorder (CVR)[11] and a Digital AIDS Recorder (DAR). The DAR is part of the Aircraft Integrated Data System (AIDS), and had been configured by the operator to record airspeed and altitude parameters from ADIRU 1, ADIRU 2 and ADIRU 3 (the DFDR records airspeed and altitude from only one ADIRU source at any one time). The CVR records four channels of audio and is located at the rear of the aircraft. On G-EUPO, three of the audio channels are connected to the audio management system, for the recording of radio transmissions, cabin announcements and audio from the commander's and first officer's microphones. The fourth audio channel is connected to a Cockpit Area Microphone (CAM), which is located at the front of the overhead panel. The CAM signal is pre-amplified before being provided to the CVR, with the pre-amplifier located above and to the right of the overhead panel. All four channels are provided to the CVR as analogue signals, which are electrically routed the length of the aircraft.

DFDR and DAR data was available for the entire incident flight, with the CVR record commencing at

Footnote

[11] Honeywell manufactured solid state memory CVR, part number 980-6022-001.

1214 hrs and ending shortly after the aircraft had been shut down at Luton Airport. Salient parameters during the approach into London Heathrow and the landing at Luton are contained in Figure 3.

Abnormal sound pulses on CVR Cockpit Area Microphone (CAM) channel

The CVR CAM record was found to contain four periods where brief[12], abnormal sound pulses had been recorded. The same sounds were not present on the other channels, and the flight crew had not referred to hearing any unusual sounds during the flight. The pulses occurred at varying rates, from between five times per second to just less than once every three seconds, and were consistent in generating high amplitude broadband sound pulses. The CVR manufacturer was consulted regarding the serviceability of the unit; no defects were identified.

The sound pulses first occurred at 1255:21 hrs. Thirty four seconds later, at 1255:55 hrs, the ECAM message ANTI ICE CAPT TAT and ANTI ICE CAPT R STAT appeared. Within the minute of 1255 hrs, the CFDS failure message NO PHC 1 DATA was also recorded. The pulses then ended at 1256:40 hrs. The second occurrence started at 1258:17 hrs and ended at 1258:29 hrs, during which the wing anti-ice was selected ON. At 1258:50 hrs the sound re-occurred over a period of two seconds before the fourth and final occurrence which commenced at 1300:20 hrs and ended at 1302:16 hrs. During this period, the CFDS failure message NO PHC 3 DATA was recorded at 1301 hrs, and at 1302:05 hrs, an ECAM message ANTI ICE STBY R STAT appeared. Almost immediately before the ECAM message appeared, the flight crew selected the wing anti-ice to OFF.

The AAIB had not observed a sound having the same characteristics before. To aid in its identification, a sample audio clip was provided to the aircraft manufacturer, Bureau d'Enquetes et d'Analyses Pour la Securité de l'Aviation Civile (BEA) and the CVR manufacturer.

The aircraft manufacturer advised that it had not previously heard such a sound before. The BEA compared the sounds with CVR records from other aircraft, which had experienced atmospheric static discharges. However, the characteristics of the pulses were found to be different, with sounds induced onto the CVR being much more variable in amplitude.

The CVR manufacturer advised that it had recently been notified of a "popping" sound appearing on the CAM channel of a CVR equipped to a different aircraft type. The CVR manufacturer had tested both the same model of CVR equipped to G-EUPO and its latest CVR model. Under laboratory conditions, it was confirmed that this CVR's CAM microphone and associated control panel, which contained the CAM pre-amplifier, were all working correctly. However, by applying an Electrostatic Discharge (ESD) to the connector of the CAM control panel, the "popping" sound could be replicated on the CVR. The CVR manufacturer applied similar discharges to the wiring harness, but were unable to replicate the sound. Specific details were not available, although a faulty unit, which was located near to the CAM on the other aircraft type, was found to have been causing electrical interference. The CVR manufacturer's opinion was that the sounds produced on G-EUPO's CAM channel during the incident flight were a consequence of electrical interference.

In November 2011, the operator performed a download of the CVR equipped to G-EUPO. The record was checked and no abnormal sounds were identified.

The source, or sources, of the sound pulses during the incident flight could not be identified.

Footnote

[12] The sound pulse duration was less than 50 milliseconds.

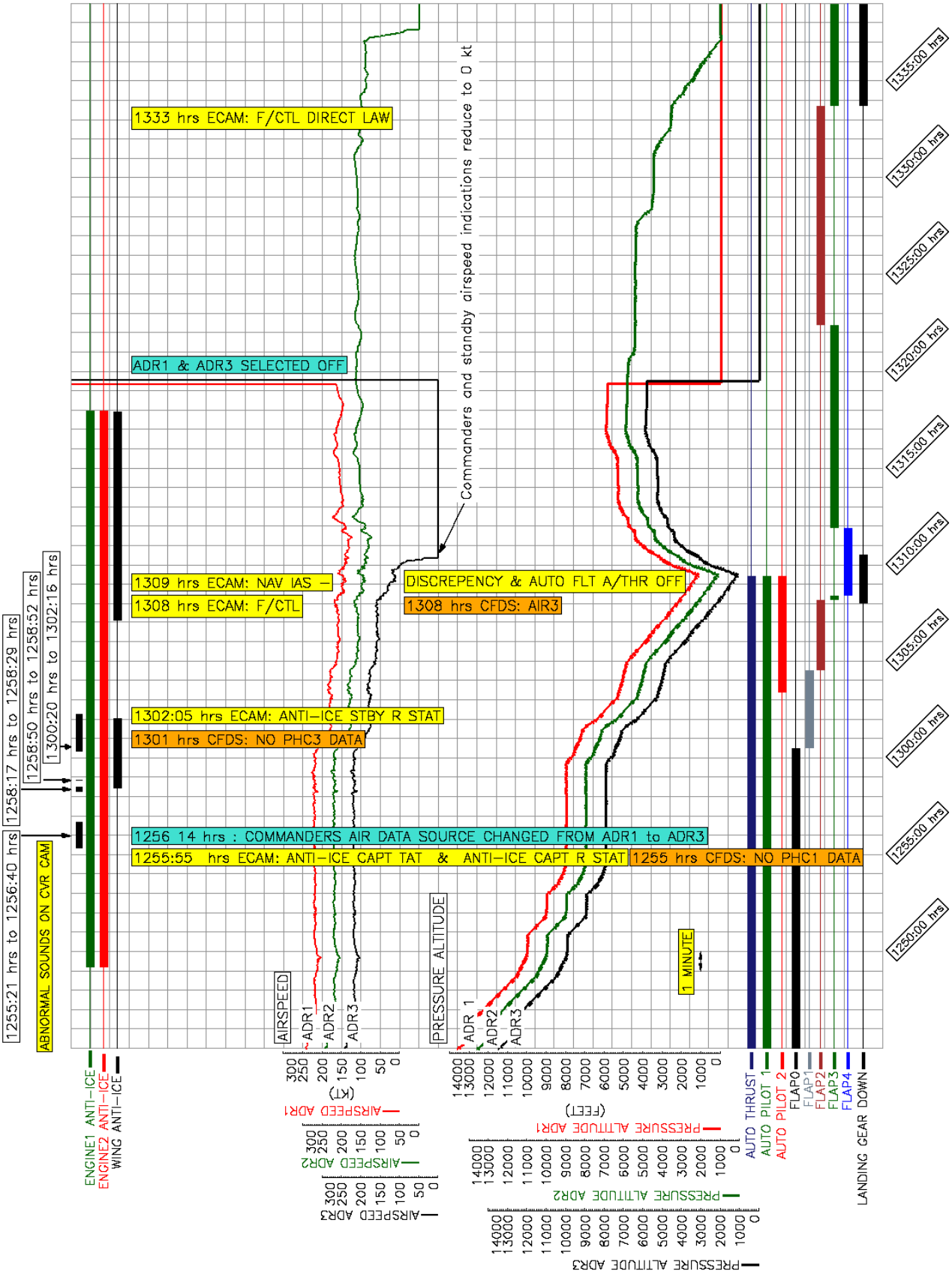


Figure 3

Approach to London Heathrow and landing at Luton Airport

Maintenance actions

Following the incident, the operator, in consultation with the aircraft manufacturer, undertook an extensive examination and testing of the air data system that included the following:

- A BITE test was run, from the CFDS, on CPC 1 prior to resetting it by operating the power supply CB. No BITE messages were present and no faults were identified.
- A BITE test was run from the CFDS on ADR1. No BITE messages were present and no faults were identified.
- The BITE messages on PHC 1 and PHC 3 were checked from the CFDS prior to a BITE test being run. There were no BITE messages on either PHC, and no faults were detected during the test nor any difficulties experienced with the communication between the PHCs and the CFDIU. All these checks were carried out prior to any change of the status of the LGCIU.
- All the probe and AOA sensors were visually inspected which found to be serviceable. All the drain holes were found to be clear of any restrictions.
- A pressure leak test was carried out on the stby pitot probe which was found to be within limits. The stby pitot probe was then replaced.
- The power supply to PHC 1 was tested and found to be within limits.
- Electrical resistance checks were carried out between PHC 1 / PHC 3 and the right stby and the Capt pitot probe.
- The stby airspeed indicator was replaced.

PHC 1 and 3 were replaced and tested by both the PHC manufacturer and the aircraft manufacturer. The tests identified no faults on either unit.

Despite the extensive engineering investigation, the faults that generated the ECAM messages could not be reproduced and all the tests and inspections indicated that the aircraft system and components were serviceable.

Review of fault history

A review of the aircraft fault history revealed that G-EUPO had experienced a number of faults over a number of flights, which might have been related to those observed during the incident flight.

On 14 December 2010, 30 December 2010, 1 January 2011 and 2 January 2011 the ECAM warning CAB PR SYS 1 was displayed during the early phase of the flight. In all cases CPC 1 identified a fault with PRESS CONTR 1. Subsequent BITE tests were satisfactory indicating a serviceable system. On 7 January 2011 the crew reported a CAB PR SYS 1 ECAM message on both flights that day. The operator replaced CPC 1 and there have been no further reports of this ECAM message.

6 January 2011. The stby ASI was reported as under-reading by 8 kt. The stby ASI was replaced. The aircraft manufacturer advised the investigation that the under-reading was within tolerance.

7 January 2011. The crew reported that the captain's right static port failed in descent whilst passing FL 350, with anti-ice selected ON. The PFR contained the following warnings and messages:

- CAB PR SYS 1 FAULT
- ANTI-ICE CAPT R STAT
- ANTI-ICE CAPT TAT
- NAV ALT DISCREPANCY
- AUTO FLIGHT A/THR OFF
- NO PHC 1 DATA (source CFDS)
- PRESS CONTR 1 (source CPC 1)

During the subsequent engineering investigation, the operator's engineers were unable to interrogate PHC1 through the CFDS until they had reset the CB for PHC. When the BITE was run, the PHC was found to be serviceable. ADIRU 1 and 3 were interchanged and the PFR message changed to ANTI ICE STBY and no PHC 3 DATA. PHC 1 and PHC 3 were interchanged and the aircraft released for further flight. ADIRU 3 was subsequently replaced on 22 January 2011 when spares became available and returned to the operators overhaul facility for further testing. The testing found the unit to be serviceable and it was subsequently fitted to another aircraft on 6 February 2011 and has since operated satisfactorily.

15 January 2011. While there was no tech log entry for any ECAM messages occurring during the flight, the following PFR messages were generated:

- ANTI ICE STBY PITOT
- ANTI ICE STBY AOA
- ANTI ICE STANDBY L STAT
- NO PHC 3 DATA (source CFDS)

The operator advised that as no tech log entry had been raised, no work had been carried out to determine why the PFR responses had been generated.

28 June 2011. A Capt TAT ECAM warning appeared during the flight. The associated PFR message was CHECK TAT PHC1 SUPPLY (source PHC 1). The operator undertook a probe heat test and, as the current was within limits, took no further action.

4 July 2011. The crew reported that an ANTI ICE CAPT PROBES ECAM warning appeared after the aircraft landed. There was no associated PFR fault message. The operator undertook a BITE test of PHC 1, through the CFDS, which identified no faults in the system. No further action was taken.

16 July 2011. The crew reported that an ANTI ICE F/O R STAT ECAM message appeared on power transfer after engine start and a F/O TAT ECAM message appeared after takeoff. The relevant warnings and fault messages recorded on the PFR were:

- ANT ICE F/O TAT
- MAINTENANCE STATUS F/CTL
- ADR2
- ADIRU2 (1FP2) (source ADR and ident EIS 2, AFS)
- NO BSCU 1 DATA (INTM) (source CFDS)
- NO PHC2 DATA (source CFDS)
- SEC2 OR BUS 2 FROM ADR2 (source EFCS 2 ident EFCS 1)
- AFS:ADIRU 1/2/3 DISAGREE (source AFS)
- SEC3 OR BUS2 FROM ADR3 (source EFCS 2 ident EFCS 1)
- AFS: ADIRU2 (source AFS)
- ADM2 (19FP2) (source ADR 2)

The aircraft manufacturer advised the investigation that the number of probe heating faults that occurred on G-EUPO over this time period was significantly higher than seen on other the A319/A320/A321 aircraft.

Analysis

Event flight

The crew's account of the sequence of events was consistent with the data recorded on the PFR, the DFDR and the DAR.

At the time of the incident, the aircraft manufacturer was undertaking a technical investigation (TFU 21.25.34.003) into the generation of a spurious ECAM warning, VENT AVNCS SYS FAULT, on A318, A319, A320 and A321 aircraft. This fault was assessed by the aircraft manufacturer as being unrelated to the ECAM warnings concerning the air data that occurred on G-EUPO.

The CAB PR SYS 1 FAULT that occurred in the initial part of the climb also occurred at this stage of flight on other occasions. The replacement of CPC 1 on 7 January 2011 appeared to have cleared this fault.

According to the PFR, the ECAM cautions ANTI ICE CAPT TAT and ANTI ICE CAPT R STAT were both associated with the failure message NO PHC 1 DATA that was generated by the CFDS. This message only indicated that the CFDS was not receiving any data from PHC 1 and was not an indication of the serviceability state of the PHC. Post-flight testing of PHC 1 did not identify any BITE messages or faults that could have resulted in these warnings.

In response to the initial anti-ice ECAM cautions, the crew moved the air data selector switch to Capt 3, which meant that the Captain's PFD was now supplied with air data from ADIRU 3. However, from the DFDR it could be seen that when these messages were generated, the airspeed outputs from ADIRU 1, ADIRU 2 and ADIRU 3, were all within two knots of each other. This indicates that the Capt air data sensors, ADMs and communication paths to ADIRU 1 were serviceable with no evidence of ice collecting on the probes.

Approximately seven minutes later, the ECAM caution ANTI ICE STBY R STAT was displayed and, according to the PFR, was associated with the failure message NO PHC3 DATA, generated by the CFDS. This also indicated that the CFDS was not receiving any data from PHC 3. Post-flight testing of PHC 3 did not identify any BITE messages or faults that could have resulted in this warning. At this time, there was no degradation of the airspeed outputs from ADIRU 1, ADIRU 2 and ADIRU 3 recorded on the DAR, indicating that there was no ice accumulation on the probes and the air data system was serviceable.

Approximately six minutes later, the PFR shows the ECAM message MAINTENANCE STATUS F/CTL, the associated failure message ADR 3 was generated by EFCS 2 and confirmed by EFCS 1 and the AFS. This message indicated that EFCS 1, EFCS 2 and the AFS had identified that there was a discrepancy between the airspeed outputs from ADIRU 1, ADIRU 2 and ADIRU 3. Data from the DFDR showed the airspeed output of ADIRU 3 reducing, with the airspeed output from ADIRU 1 and ADIRU 2 remaining within two knots of each other at about 140 kt. A NAV IAS DISCREPANCY warning was generated by the FWC which indicated that there was a discrepancy between the airspeed displayed on the Capt and F/O PFDs. At the same time the crew reported that the speed displayed on the Capt PFD decayed to around 50 to 60 KIAS and the stby ASI fell simultaneously to 0 KIAS. Less than two minutes had elapsed between the initial discrepancy being detected and the airspeed output from ADIRU 3 decaying to 0 kt. About the same time the PFR records the failure message DMC 1: NO ADC3 DATA; this would have been generated as a result of the air speed

data from ADIRU 3 dropping below 30 kt. The stby ASI and ADIRU 3, which was now supplying the Capt PFD, were both using air pressure information from the stby pitot and static probes. The recording on the DAR and the indications reported on the Capt PFD and stby ASI were consistent with possible icing of the stby pitot probe.

The crew determined, using the UNRELIABLE SPEED INDIC/ADR CHEC procedure from the QRH, that ADR 2 was the only reliable source of air data and, therefore, turned ADR 1 and ADR 3 OFF. In fact, the data from ADR1 was still reliable but the earlier ANTI ICE CAPT R STAT and ANTI ICE CAPT TAT caution messages and associated ECAM actions had meant that the commander had selected CAPT 3, so ADR1 data was no longer being presented to the crew. Therefore, they were not able to determine its serviceability without reversing the previous ECAM actions.

Switching off the ADR1 and ADR3 resulted in the following ECAM messages shown below in Table 3 and the reconfiguration of the flying control protection into Alternate and then Direct Law.

The post-flight testing and the data from the flight all indicate that the aircraft experienced two independent faults during the approach to Heathrow airport: icing of the stby pitot probe and loss of data communication, over a 6 minute period, between PHC 1, PHC 3 and the CFDIU. PHC 1 and 3 were powered from different electrical busbars and had separate communication links that did not pass through the same connectors. The aircraft manufacturer advised the investigation that they were unaware of any other occurrences of the loss of communication between two of the PHCs and the CFDIU during one flight.

At the time that both PHC1 and PHC3 had stopped communicating with the CFDIU, sounds identified as being induced by electrical interference were recorded on the CVR CAM channel. Analysis of the sounds indicated that the interference was most probably internal to the aircraft, and although it cannot be ruled out that the interference was generated elsewhere within the aircraft, it is possible that the interference was associated with the loss of the PHC1 and PHC3 communications with the CFDIU.

F/CTL ALTN LAW	As a result of switching off ADR 1, and the loss of ADR 3, there was only one source of air data from ADR 2.
NAV ADR 1 FAULT	A result of turning off ADR 1.
AUTO RUD TRV LIM	A result of turning off ADR 1, the Flight Control Computer no longer had a reliable source of data and therefore stopped computing the rudder travel limit.
MAINTENANCE STATUS SFCS	This message is generated after the aircraft has landed and is associated with the ADR fault message.
NAV ADR 1 + 3 FAULT	A result of turning off ADR 1 and ADR 3.
F/CTL DIRECT LAW	The FCS automatically goes into Direct Law when the landing gear is lowered and the FCS is already operating in Alternate Law.
F/CTL ALTERNATE LAW	The FCS automatically reverts back to Alternate Law once the aircraft lands.

Table 3

ECAM messages

Other occurrences

There are similarities between the event flight and the other occurrences on G-EUPO. The air data probe and static port warnings are generally accompanied with a fault message that there is a loss of data from one of the three PHCs. Yet BITE tests of the ADIRU and PHC following the occurrences could find no faults within the systems. The three PHC are all independent, using different power supplies and data buses to communicate with the CFDS which appears to be the only common system in all the occurrences.

Comment

The faults arising indicated that there was an intermittent communication fault between the PHCs and the CFDIU. In the majority of occasions these were dealt with by maintenance action which showed the systems to be serviceable. However, during the event flight it would appear that this intermittent fault occurred at the same time as the icing of the stby pitot probe. This then resulted in the loss of airspeed information on the commander's and standby flight instruments at a late stage of an instrument approach under demanding weather conditions. This led to an increased crew workload and a declaration of a MAYDAY by the commander. The ECAM and QRH procedures, as carried out, also resulted in a reconfiguration of the flight controls system during the diversion.

The safe flight path of the aircraft was maintained at all times under challenging circumstances and a diversion and uneventful landing were carried out at the alternate airport.

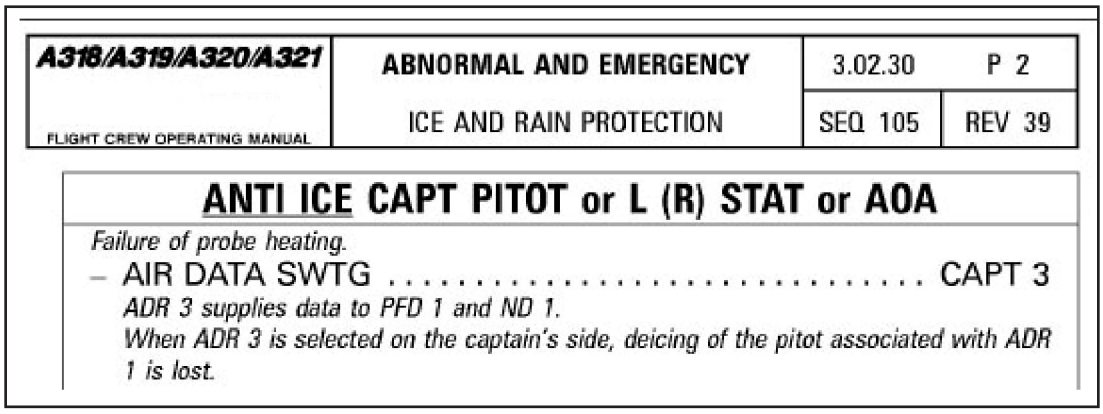
Safety action

Flight Crew Operating Manual

During the investigation the aircraft manufacturer identified that the manufacturer's Flight Crew Operating Manual (FCOM) entry, regarding the loss of deicing to the pitot associated with ADR1 when ADR 3 is selected on the captain's side, was incorrect (Figure 4). This did not affect the crews handling of the emergency and was, therefore not a causal factor in this incident. An amendment to the FCOM has been issued by the manufacturer.

Safety Recommendation

During the investigation the crew reported an anomaly with the UNRELIABLE SPEED INDIC/ADR CHECK in the QRH. Although this did not affect the safe conduct of the flight it could have an influence on the outcome of future similar events.



A318/A319/A320/A321 FLIGHT CREW OPERATING MANUAL	ABNORMAL AND EMERGENCY ICE AND RAIN PROTECTION	3.02.30 SEQ 105	P 2 REV 39

ANTI ICE CAPT PITOT or L (R) STAT or AOA

Failure of probe heating.

– AIR DATA SWTG ..... CAPT 3

ADR 3 supplies data to PFD 1 and ND 1.
When ADR 3 is selected on the captain's side, deicing of the pitot associated with ADR 1 is lost.

Figure 4

The procedure is presented over five pages of the QRH (Figure 5). The first page contains the memory items, which are required to be carried out if the safe conduct of the flight is affected, to establish the aircraft in a climb. It then provides the pitch/thrust settings for the initial level off. However, this procedure did not contain information for configuration FULL, the configuration that the aircraft was in at the time of the go-around. Thus, when the crew attempted to carry out the initial level off using the QRH, there was no guidance. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2011-099

It is recommended that Airbus amend the UNRELIABLE SPEED INDIC/ADR CHECK procedure in the A320 Quick Reference Handbook and the Flight Crew Operating Manual to ensure that it meets the requirements for all phases of flight.

The aircraft manufacturer has advised that they:

'will clarify the go-around procedure handling if the unreliable airspeed condition appears in final approach and this will be made available to operators in April 2012.'

UNRELIABLE SPEED INDICATION/ADR CHECK PROC

● **If the safe conduct of the flight is impacted** :

MEMORY ITEMS
- AP/FD ..... OFF
- A/THR ..... OFF
- PITCH/THRUST :
  - Below THRUST RED ALT ..... 15°/TOGA
  - Above THRUST RED ALT and Below FL 100 ..... 10°/CLB
  - Above THRUST RED ALT and Above FL 100 ..... 5°/CLB
- FLAPS ..... Maintain current CONFIG
- SPEEDBRAKES ..... Check retracted
- L/G ..... UP

● **When at, or above MSA or Circuit Altitude** :
- Level off for troubleshooting

- GPS ALTITUDE ..... Display on MCDU

● **To level off for troubleshooting** :
- AP/FD ..... OFF
- A/THR ..... OFF

NOTE : Check the actual slat/flap configuration on ECAM, since flap auto-retraction may occur.

PITCH / THRUST FOR INITIAL LEVEL OFF

SLATS / FLAPS EXTENDED				
		Above 66 t	66 t – 56 t	Below 56 t
CONF	Speed	Pitch (°) / Thrust (% N1)		
3	F	7.0 / 62.0	7.0 / 57.9	7.0 / 52.6
2	F	8.5 / 61.8	8.5 / 57.6	8.5 / 52.3
1+F	S	3.5 / 60.6	3.5 / 56.4	4.0 / 51.5
1	S	7.5 / 60.1	7.0 / 55.7	7.0 / 50.9
CLEAN				
FL	Speed	Pitch (°) / Thrust (% N1)		
Below FL 200	250 kts	4.0 / 64.3	3.0 / 62.0	2.0 / 60.?
FL 200 – FL 320	275 kts	2.5 / 78.0	2.0 / 76.3	1.5 / 74.8
Above FL 320	M 0.76	3.0 / 84.2	2.5 / 82.6	2.0 / 80.4

Figure 5

Further action

The aircraft manufacturer has arranged for further laboratory tests to be conducted on a PHC and CFDIU. They will also continue to monitor the A320 family of aircraft for any similar occurrences of ANTI ICE warnings being associated with the fault message NO PHC DATA. In addition the aircraft manufacturer and operator will continue to monitor for further occurrences of ANTI-ICE ECAM warnings associated with NO PHC DATA.