

Bundesstelle für Flugunfalluntersuchung

German Federal Bureau of Aircraft Accident Investigation



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BFU23-1167

Date:

18.06.2024

Subject: Diamond DA-40 NG Aircraft Accident in Asheville, NC, Dec 14 2023 – Request for Readout of Engine Data from damaged Austro Engine Electronic Engine Control Unit (EECU)

Laboratory Report

According to ICAO Annex 13, chapter 5, the German Federal Bureau of Aircraft Accident Investigation (BFU) supported the National Transportation Safety Board (NTSB) in their safety investigation involving a Diamond DA-40 NG aircraft for engine data readout of a damaged Austro Engine Electronic Engine Control Unit (EECU).

In this report the conditions of the EECU at arrival, the readout process and the results obtained are described.

The EECU was sent in a closed and sealed packaging and was opened and handled exclusively by the BFU laboratory. The NTSB agreed to the preparation (flash memory removal) and readout process proposed by the BFU beforehand and described herein.

1 General information on the exhibits

1.1 Austro Engine EECU

BFU Exhibit No.	01063
Serial Number S/N	-
Part Number P/N	-
Description	The Austro Engine EECU is a full authority digital engine control unit. It controls all aspects of the engine performance. The associated engine is a E4-series jet fuel piston engine. The EECU consists for redundancy of two completely independent circuit boards. Each board records an event log and a data log with a total of 24 engine parameters, such as engine RPM, load lever position etc. The recording frequencies for those parameters is 1 Hz. A total of four NOR flash memories (two for each board, Spansion S29CD032JOMQFM01, 32 Mbit density) are used to store the above data on the EECU. The memories are soldered to the respective board, one on each side (80-pin PQFP).
Condition	The EECU printed circuit boards (PCB) were severely damaged at arrival in the BFU lab. Only the PCB's (without housing) was provided to the BFU. The PCB showed heavy thermal damage resulting in loose and burned electronic components on the PCB. The PCB itself was bent, burned and with partially delaminated layers.

2 Inspection and Data Readout

2.1 Opening of the package and first visual inspection

The package with the EECU was opened at the BFU laboratory. The package contained the main PCB's of the EECU only. The EECU consists in total of three independent PCB's, one main PCB and two smaller PCB's, mainly used for capacitors. Each capacitor PCB is soldered with a total of 18 contacts (THT) to the main PCB.

The EECU was heavily damaged by heat (mainly). Several small components were already completely desoldered from the PCB. Flash memory A2 had signs of blisters and was partially lifted from the PCB. Flash memory B2 was still completely soldered to the PCB. The PCB around the flash memory B2 was less damaged by the heat than at flash memory A2's position.

Accessing and inspecting flash memory A1 and B1 is not possible without removal of the capacitor PCB's as they are hidden between the capacitor PCB's and the main PCB.

After assessing the damage of the PCB's and flash memories, the EECU was cleaned from dust and fire residuals using ultrapure isopropanol and a soft brush. All capacitors were removed from the PCB's to prevent possible short-circuit damage to the flash memories.

2.2 Desoldering of the flash memories

To access the flash memories A1 and B1, both capacitor PCB's were removed from the main PCB. For removing the PCB's, all THT contacts were desoldered and the connecting bolts removed.

The flash memory A1 was discovered desoldered and loose on the main PCB. Flash memory B1 was still soldered to the PCB with all connections intact. The flash memories A2, B1 and B2 were desoldered from the main PCB using hot air and flux.

2.3 Microscopic inspection and cleaning of the flash memories

All four flash memories were cleaned with ultrapure isopropanol and a soft brush. All contacts were also cleaned from residual flux and possible surface oxides for good readout connection with the NOR memory programmer.

No damage was detected on flash memory A1, B1 and B2. On flash memory A2 several blisters on the upper surface and a crack on the lower surface were detected. Microscopic images of those findings are included in the appendix 2 to this report.

2.4 Readout of the binary data

A universal NOR memory programmer (Dataman 48Pro2 with DIL48/PQFP80 ZIF 29BDD-1 adapter) was used to retrieve the binary data from the flash memories. The retrieval process for the flash memories A1, B1 and B2 was successful.

The internal verification check for the data from memory A2 was not successful, even though retrieval of data was possible. Nevertheless, the retrieved and partially corrupt data was further analysed. More detailed analyses showed, that several parts of the data did not correspond to the expected and usual binary pattern for the EECU data storage.

2.5 Interpretation of the binary data

The binary data from all four flash memories were interpreted and converted to a human-readable format. The conversion was done using an internal BFU software. The flash memories contained, as expected, a data and event log. Data and event logs from the accident flight were identified.

3 Results

From each board an event and data log were created. The logs are provided with this report in CSV-format (tab separated). Plots from the accident flight (board B) are included in the annex to this report. The data from board A should be handled and interpreted with care, as it contains partially corrupt data from flash memory A2.

Name	Size	Description
BFU23-1167_EECU_Board-A_Events.csv	214 KB	Event log of circuit board A and B
BFU23-1167_EECU_Board-B_Events.csv	245 KB	
BFU23-1167_EECU_Board-A_Data.csv	38.3 MB	1 Hz engine data recording of circuit board A and B
BFU23-1167_EECU_Board-B_Data.csv	43.7 MB	

Work carried out by	Martin Beckert BFU Avionics and Flight Recorders Laboratory
Report prepared by	Martin Beckert BFU Avionics and Flight Recorders Laboratory
Report checked by	Paul Kirchner Investigator, BFU Accredited Representative

Appendix 1 External Inspection

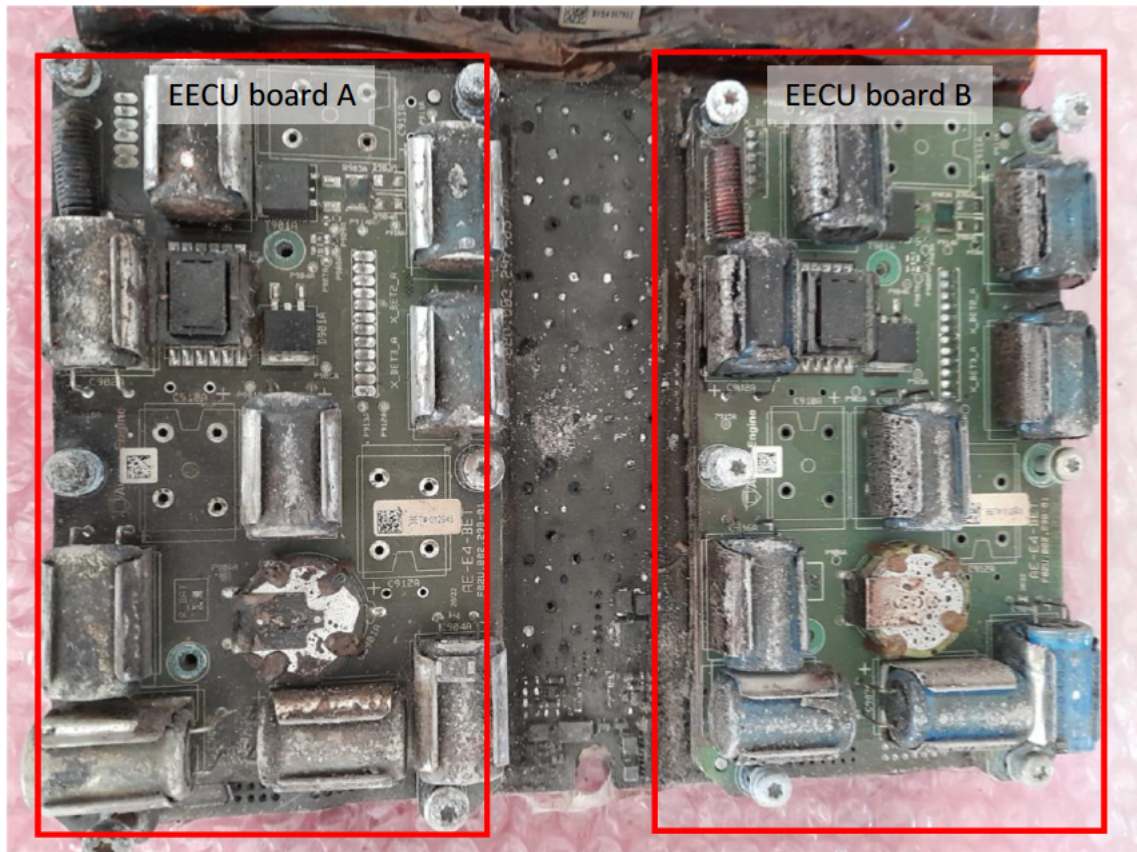


Figure 1: External Inspection – Top View

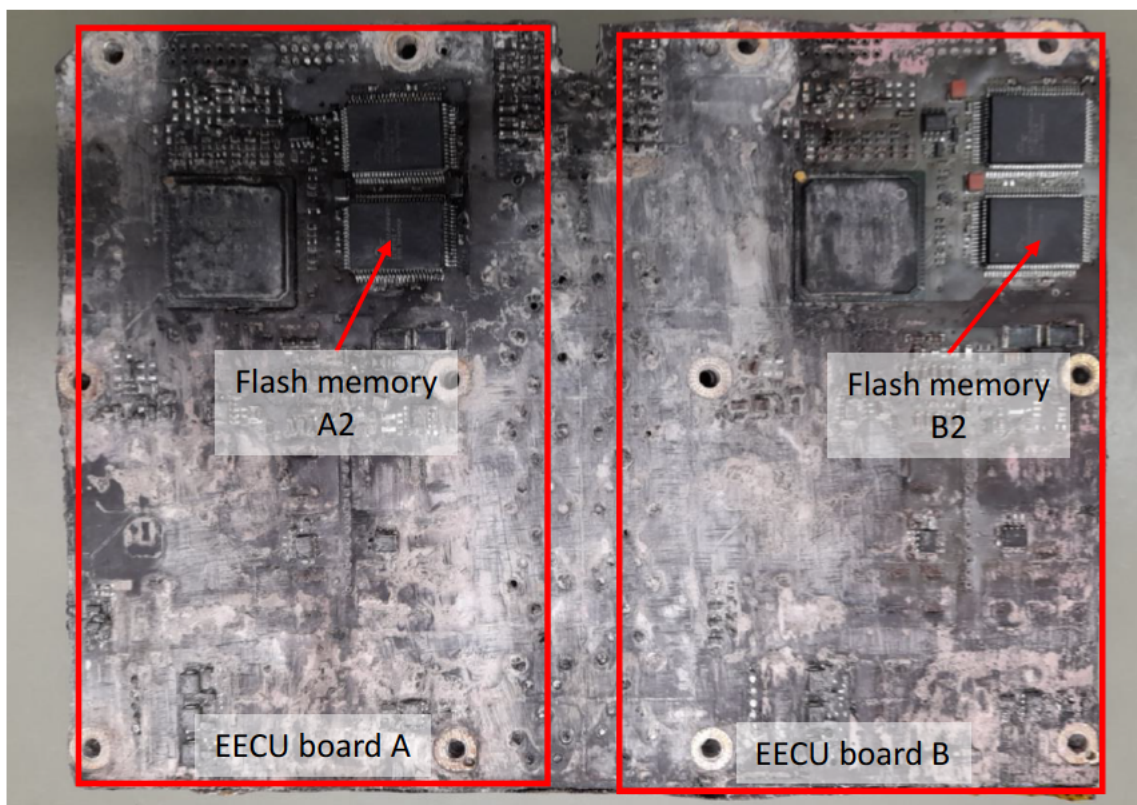


Figure 2: External Inspection – Bottom View

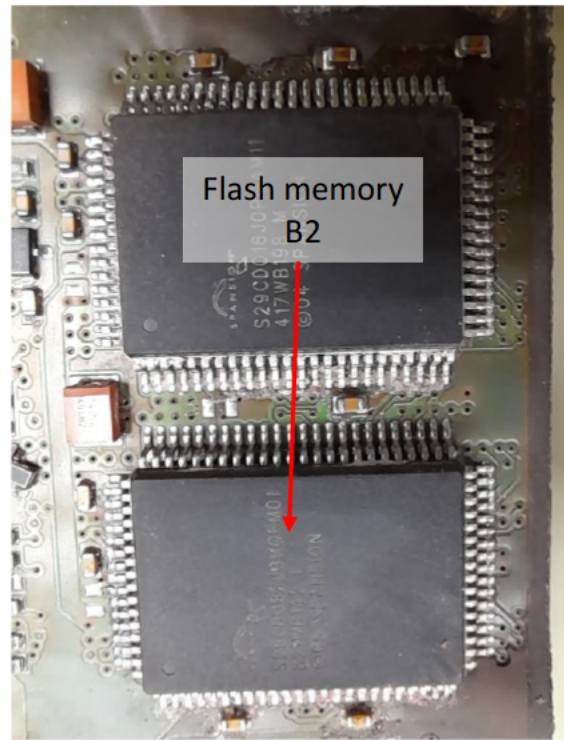
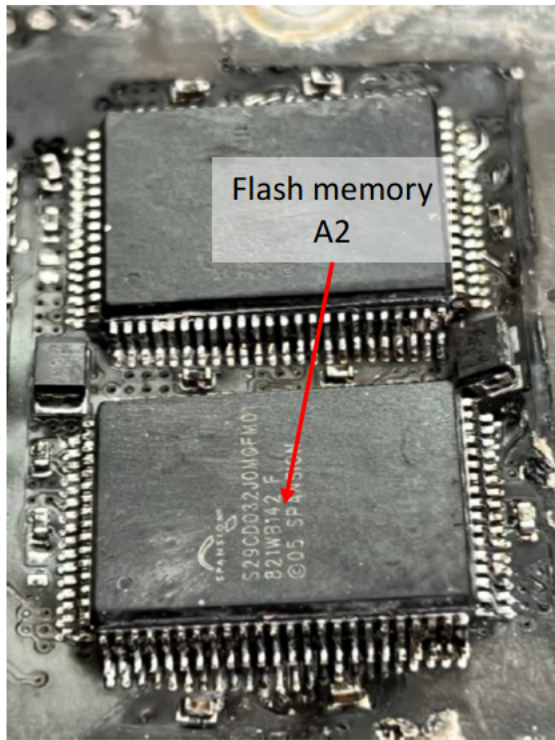


Figure 3: Detailed view flash memory A2 and B2

Appendix 2 Flash memory inspection

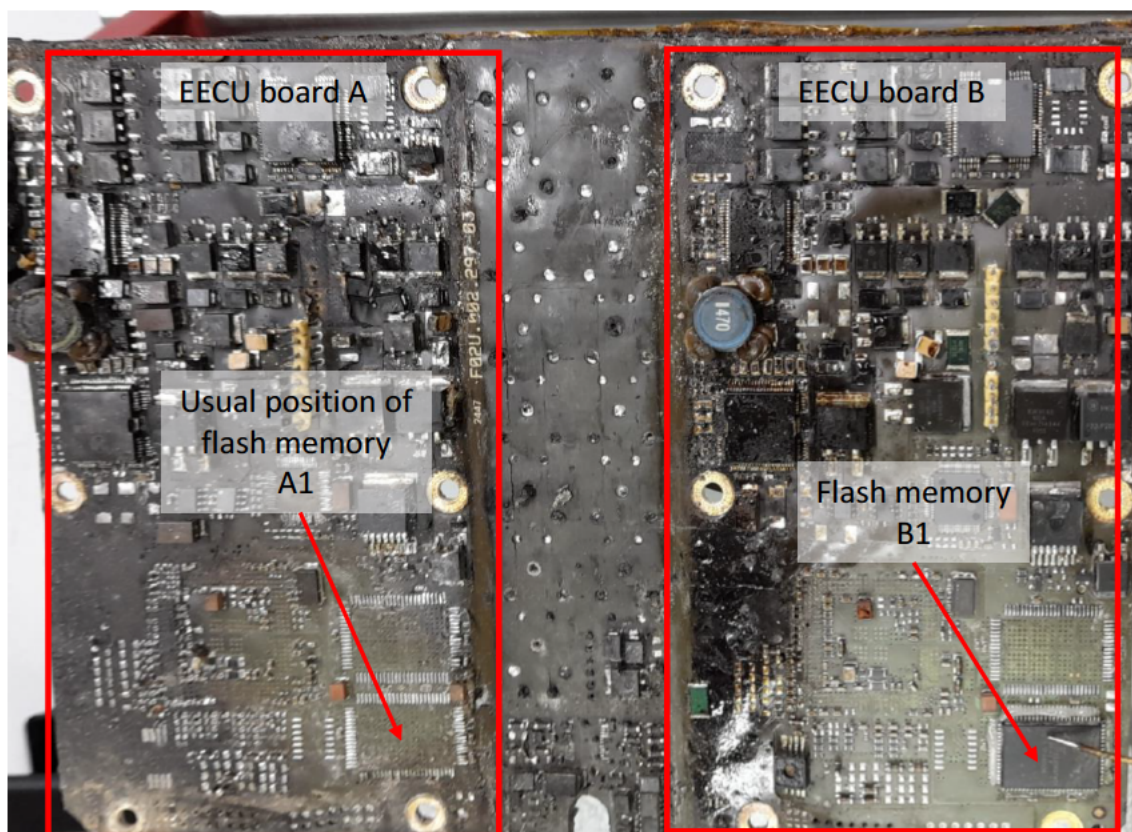


Figure 4: Main PCB after removal of the upper capacitor PCB's

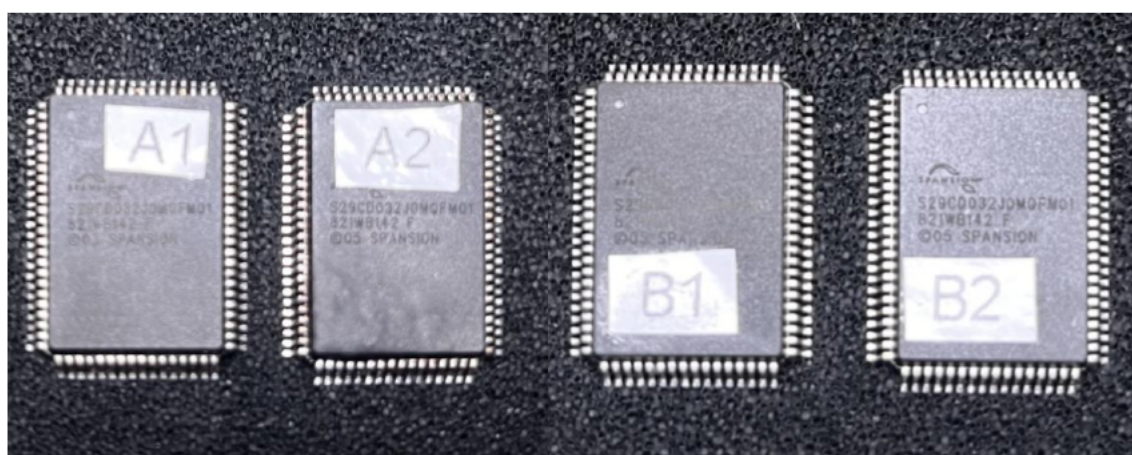


Figure 5: Flash memories after desoldering and cleaning

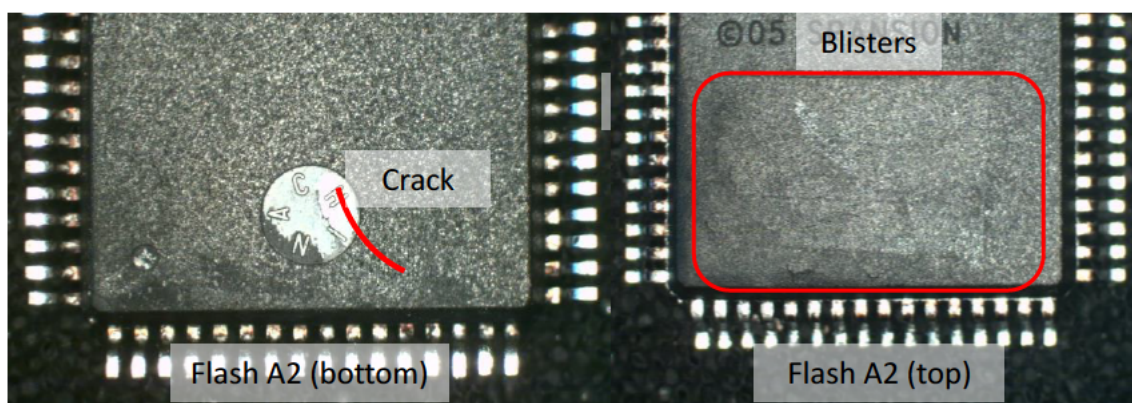
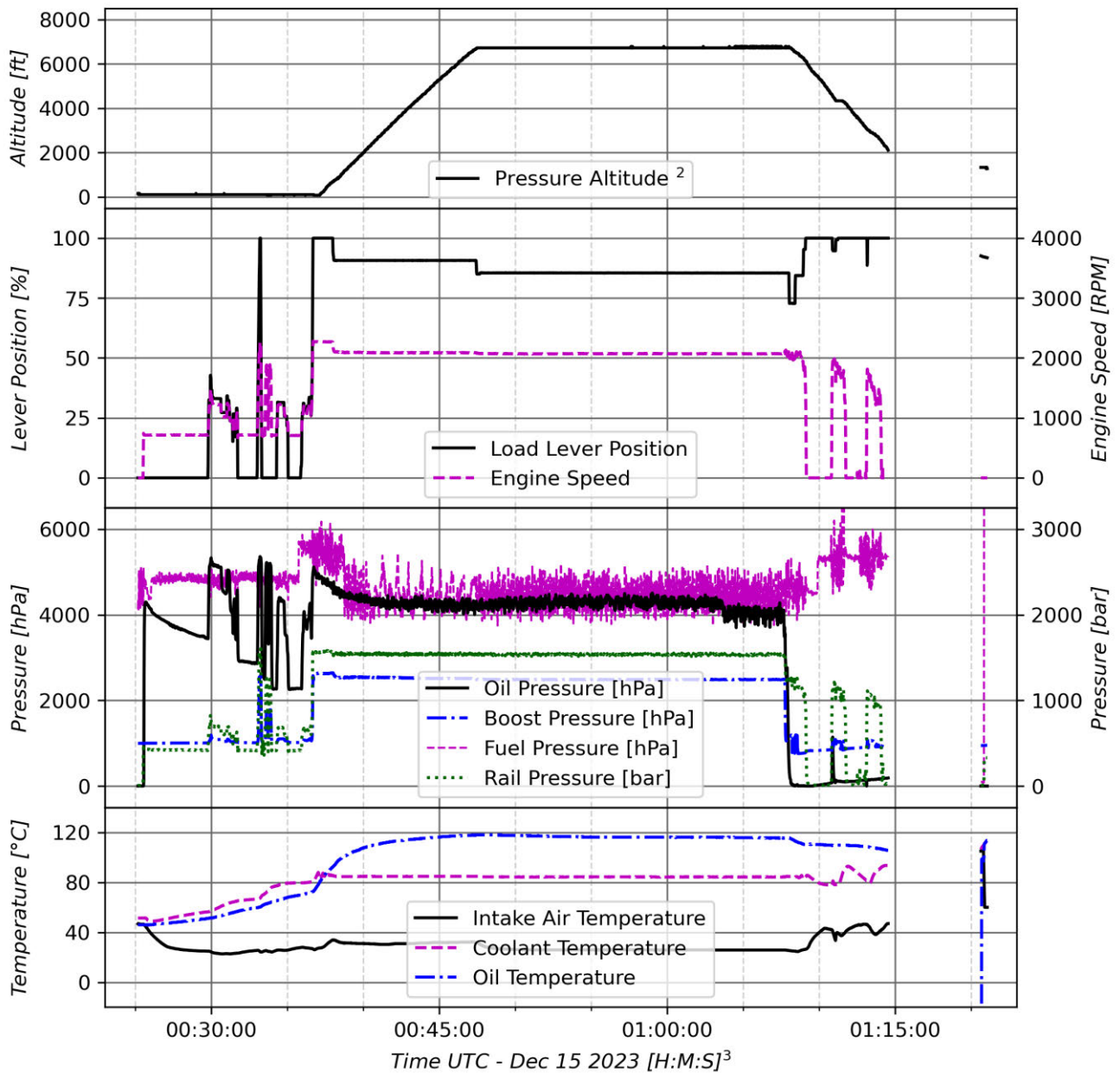


Figure 6: Microscopic findings on flash memory A2

Appendix 3 Data plots of the accident flight

BFU23-1167 | Austro Engine EECU Data Plot | Board B¹ | Flight Overview

2024-06-13 | V1.0



¹ Data based on 1 Hz flight log of the Austro Engine EECU

² Derived from EECU ambient pressure record and based on the international standard atmosphere (1013 hPa at mean sea level)

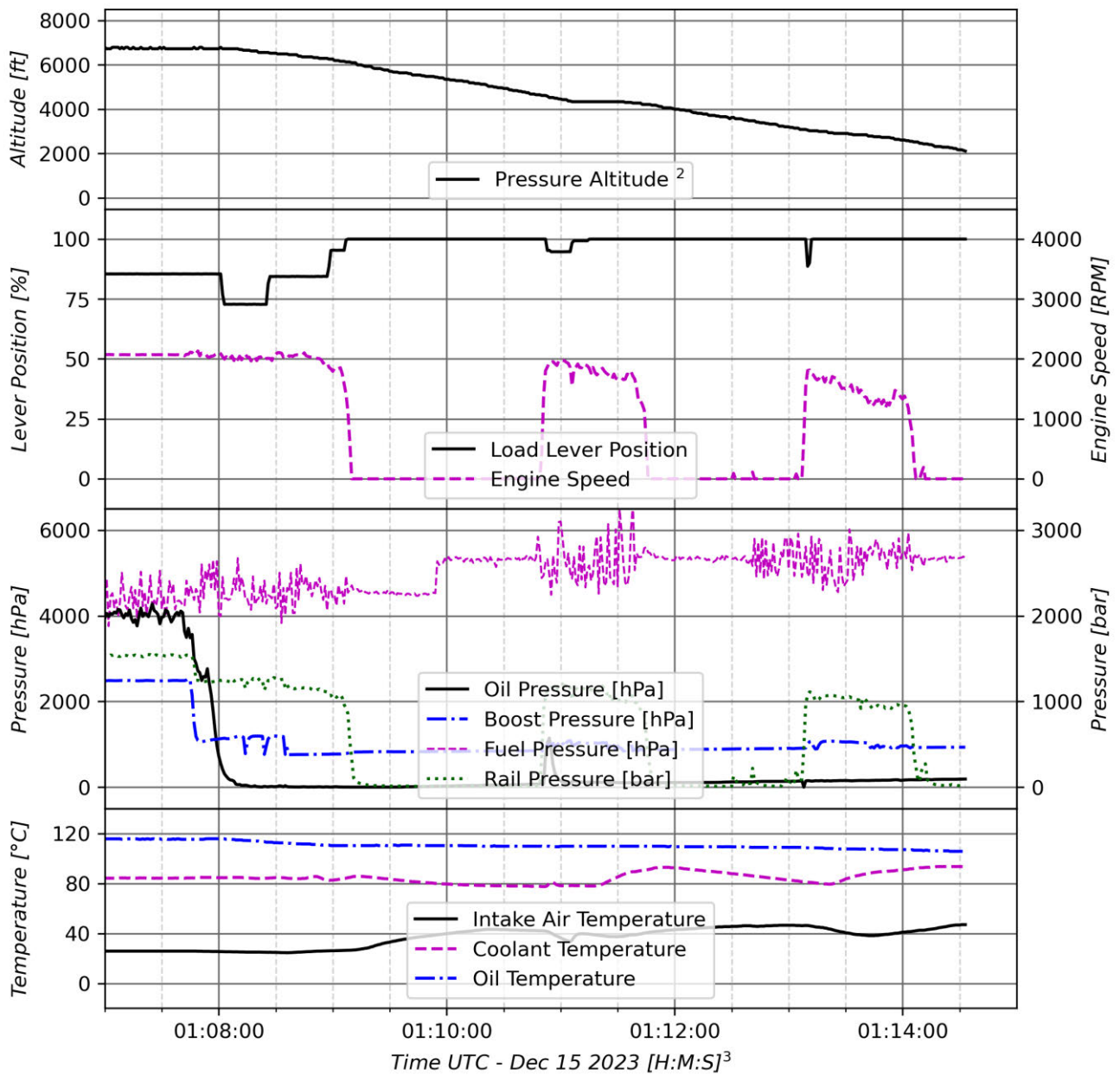
³ The time shown is the internal EECU clock time and not synchronized between boards or with an external clock. Therefore it may run slow or fast for several minutes.



Figure 7: Overview plot accident flight

BFU23-1167 | Austro Engine EECU Data Plot | Board B¹ | Descent

2024-06-13 | V1.0



¹ Data based on 1 Hz flight log of the Austro Engine EECU

² Derived from EECU ambient pressure record and based on the international standard atmosphere (1013 hPa at mean sea level)

³ The time shown is the internal EECU clock time and not synchronized between boards or with an external clock. Therefore it may run slow or fast for several minutes.



Figure 8: Detail plot accident flight (only descent)