

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division
Washington, D.C. 20594

October 27, 2021

Flight Data Recorder

**Group Chairman's Factual Report
By Charles Cates**

1. EVENT SUMMARY

Location: Las Vegas, NV
Date: May 24, 2021
Aircraft: Mirage F-1
Registration: N567EM
Operator: Draken International
NTSB Number: WPR21FA203

2. FLIGHT DATA RECORDER GROUP

A preliminary flight data recorder (FDR) group was convened on June 21-22 2021, at the National Transportation Safety Board (NTSB) Vehicle Recorder Laboratory.

Chairman: Charles Cates
Mechanical Engineer
National Transportation Safety Board

Member: Harlie Bodine
Director of Safety
Draken International

Member: John Adams
Deputy Director of Maintenance
Draken International

Member: Jason Damico
Senior Technical Advisor F-1
Draken International

Member: Jon Flickinger
F-1 Chief Pilot
Draken International

Member: Joseph Gregor
Electrical Engineer
National Transportation Safety Board

A subgroup consisting of Charles Cates, John Adams, and Joseph Gregor was reconvened on July 13, 2021 and again on October 14, 2021 for further troubleshooting and download attempts of the ESPAR recorder.

3. DETAILS OF FDR INVESTIGATION

The National Transportation Safety Board (NTSB) Vehicle Recorder Division received the following FDR:

Recorder Manufacturer/Model:	Dassault Aviation ESPAR
Recorder Serial Number:	N/A (illegible due to thermal damage)

3.1. Recorder Description

The Dassault ESPAR is a solid-state FDR customized for use with the Dassault Mirage F-1 aircraft. According to maintenance manual information, the ESPAR is capable of recording between 3-6 hours of flight data, overwriting the oldest data as new data is captured. The recorder can record 25 parameters and the readout software calculates additional parameters using the base recorded parameters.

3.1.1. Recorder Damage

Upon arrival at the Vehicle Recorder Laboratory, it was evident that the recorder had suffered mechanical impact and thermal damage. See figure 1 for the as-received condition of the recorder.



Figure 1. As-received condition of ESPAR recorder.

The recorder was disassembled, and the crash-survivable memory module was removed and inspected. Preliminary examination of the memory module showed that the module appeared to be fully intact with no heat or impact damage to the circuit boards. See figures 2 and 3 for pictures of the module extracted from the recorder. Following the removal and examination of the board, it was placed in a protective package and stored in a secure facility until the group activities began.

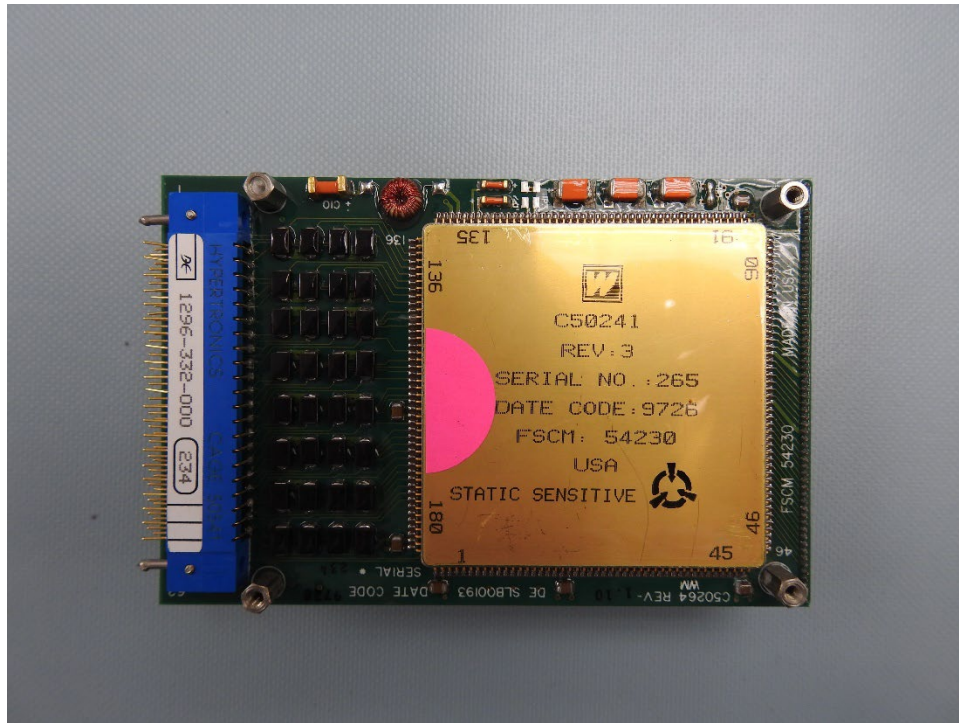


Figure 2. Memory module from accident recorder, top view.

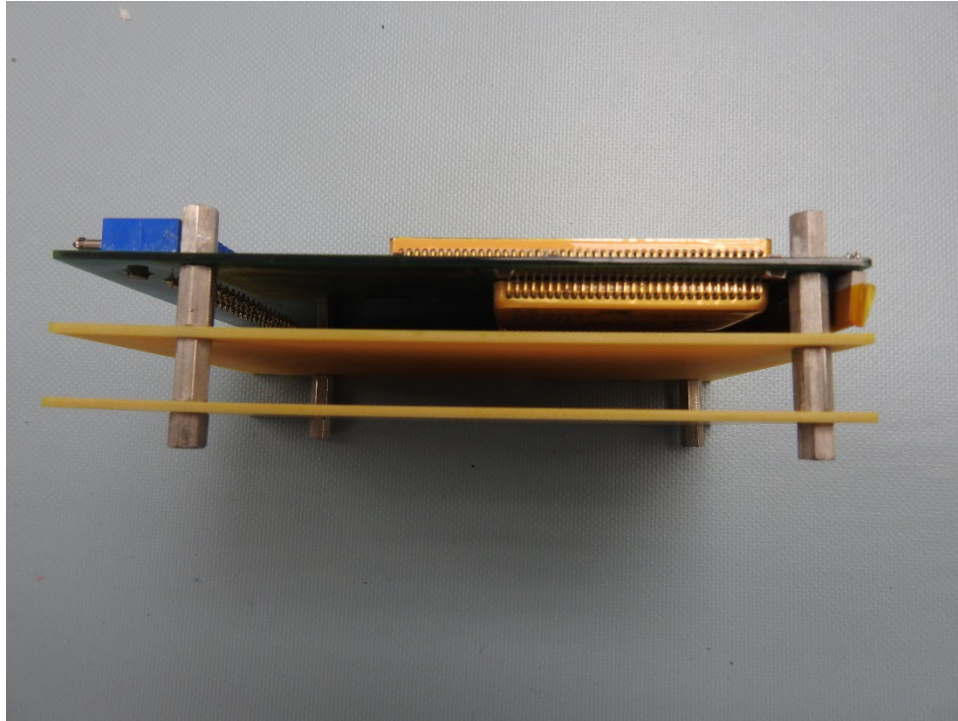


Figure 3. Memory module from accident recorder, profile view.

3.2. Group Activities and Observations

3.2.1. Summary of Initial Group Activities

The initial group activity began on June 21st 2021 at 14:30 EST, when the experts' team from Draken arrived at the NTSB Recorder Laboratory. They brought with them two known good ESPAR FDRs, readout electronics interface hardware, two laptop computers with the necessary readout software, a power supply, and cables to connect the FDR, readout hardware, and laptop computers.

Of the two functional FDRs brought by Draken, one was intact and had not been opened, and one had been disassembled and prepared for use as a Golden Chassis. Both had been tested and data was successfully extracted from the memories.

The recovery hardware was assembled and a test readout of known good memory was made. Figure 4 shows a picture of the golden chassis connected to the readout electronics and computer. The first readout attempt was made with the golden chassis using the tested and known good memory module from the golden chassis FDR to demonstrate that the hardware setup was successful. The readout was successful and the test memory module contained about 10 flight legs of stored data from an unknown aircraft.

The next step was disassembling the good FDR with the help from Draken experts and swapping the memory modules in the golden chassis. Refer to the Figures 4-6 for details.

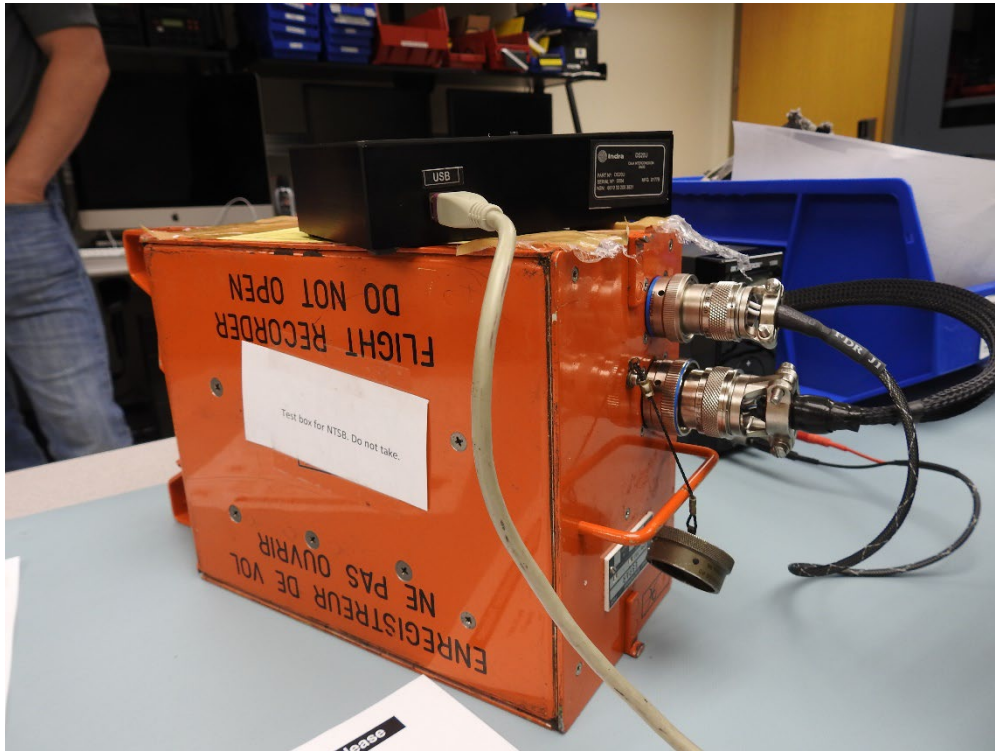


Figure 4. Golden chassis connected to the recovery hardware interface and laptop computer.



Figure 5. Memory modules swap: the known good memory is on the left and the accident memory is on the right.



Figure 6. Golden chassis with accident memory installed, view from the top.

The accident memory module was installed in the golden chassis to download in the same manner as the test module. Three attempts were made to connect to the recorder. In each attempt, the indicator showing successful connection between the computer and electronics interface illuminated as expected, however the interface was unable to successfully connect to the recorder and the connection would fail. Without a valid connection from the interface to the recorder the download attempts were unsuccessful. Between each attempt the power and data interface connections were checked and the memory modules were re-seated for verification. Every time the download failed, the software displayed a message about communication error (refer to Figure 7).

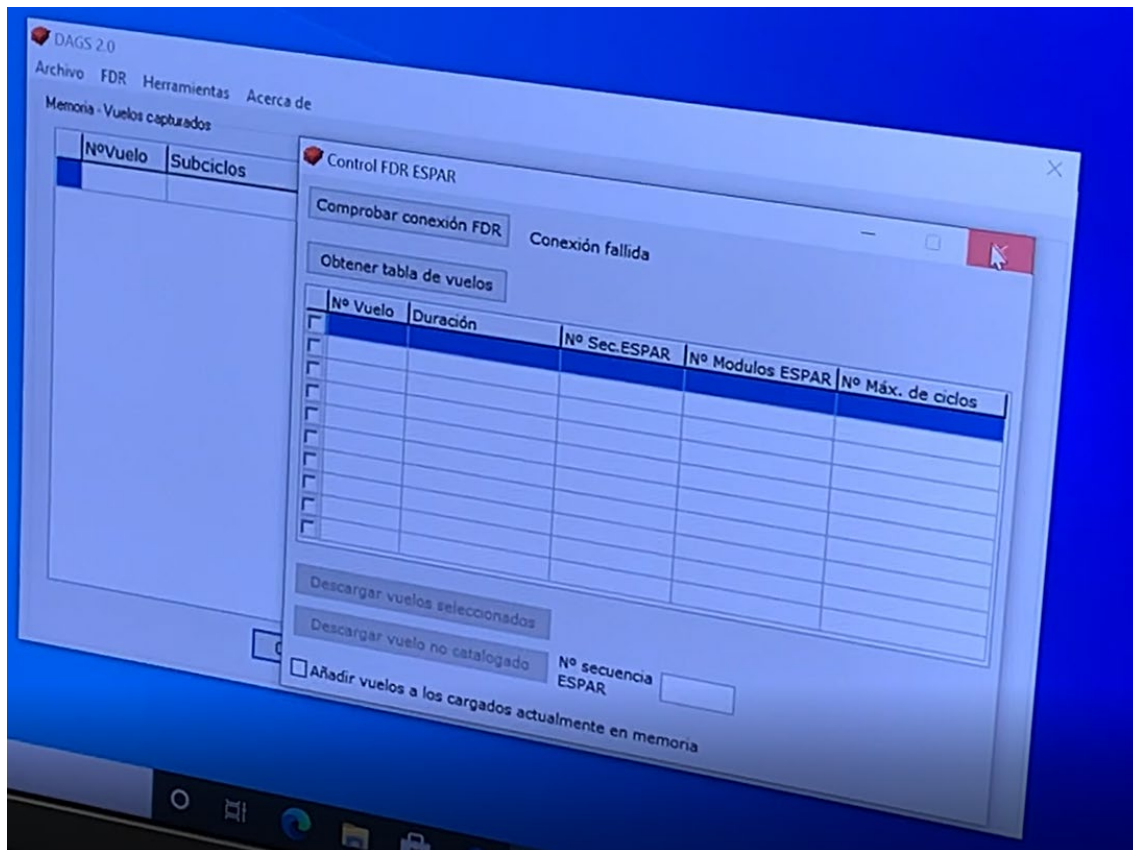


Figure 7. Readout software reporting the connection to the recorder memory failed.

As a test, the known good memory was reinstalled into the golden chassis and a successful download was completed. Additionally, the second FDR was connected to the readout interface and successfully downloaded.

On the second day of group activities a detailed memory component visual examination was conducted under microscopic-level magnification. Two minor findings were discovered. The first was possible delamination around a trace leading to the main processor. The second was that three board capacitors had signs of corrosion underneath the conformal coating of the board. The working memory module did not have similar corrosion. See Figures 8 and 9 for details.

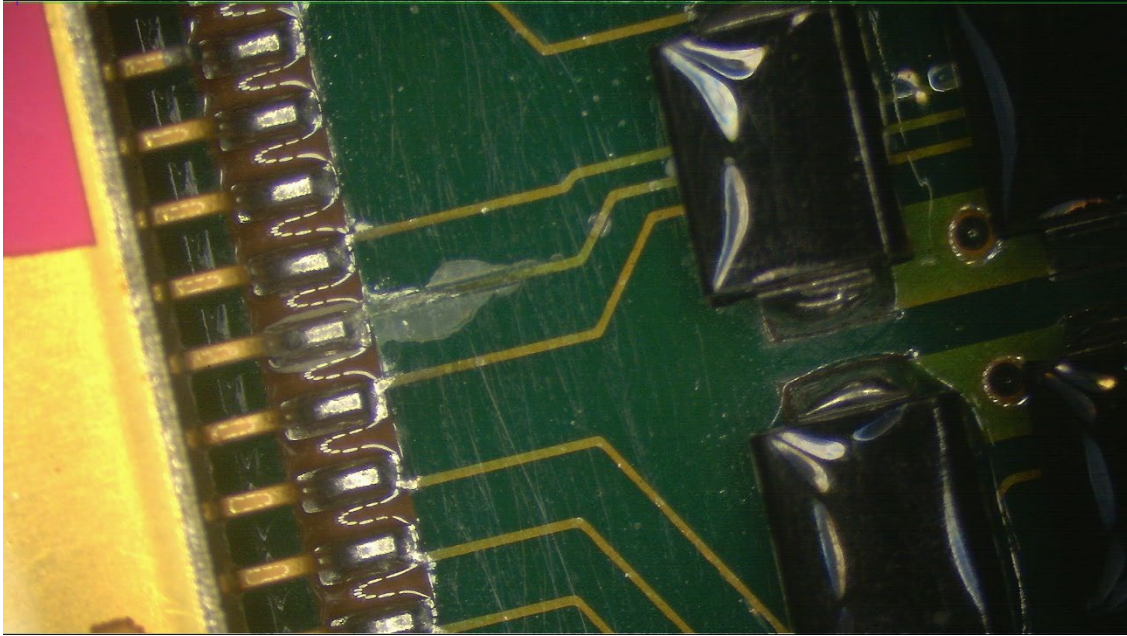


Figure 8. The sign of delamination on the trace (main board).

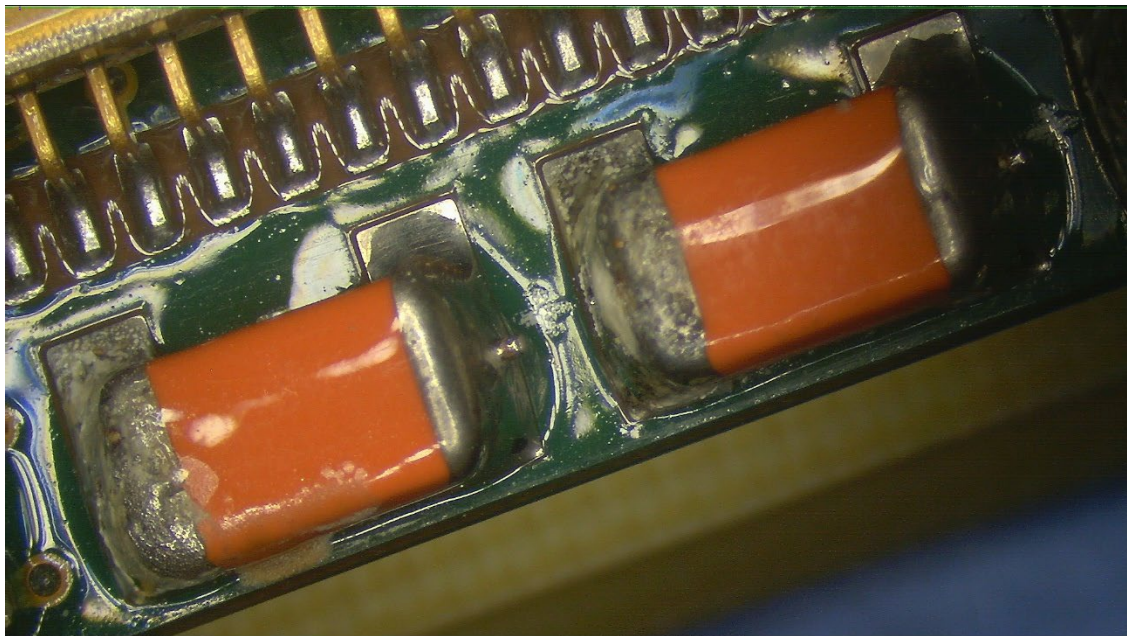


Figure 9. Capacitors with signs of minor corrosion.

As a next step, NTSB specialists performed a memory board pinout resistance mapping. The comparison identified a few mismatches between the working and accident memory modules.

3.2.2. Subgroup Meeting 1 Activities

Following the initial group meeting the aircraft manufacturer was contacted for additional information regarding the boards and their design. With the discovery of corroded

capacitors, they were removed from the board, tested, and found to be faulty. The bad capacitors were determined to be a part of the power conditioning circuit on the board and are not necessary in a laboratory environment with a clean power supply. It was hoped that their removal would then allow the board to power on for download so the first subgroup meeting to attempt another download of the accident board was arranged for July 13, 2021.

For this attempt the modules were connected as in the initial group. The first download was done with the known good memory module in the golden chassis and was successful. When the accident memory module was attempted, it failed in the same manner as the original download attempts, with a connection failure from the computer to the recorder.

3.2.3. Subgroup Meeting 2 Activities

After the second set of download attempts failed the aircraft manufacturer responded to earlier inquiries made by the NTSB and stated that they could not provide assistance or support for the device.

A plan was devised to remove the memory chips from the accident board and swap them on to the known good surrogate. In preparation for the second subgroup the conformal coating was removed from the memory chip pads of both the accident module and the surrogate. The memory chips were removed from the accident module in preparation for the second subgroup meeting on October 14, 2021.

For this third attempt the modules were connected as in the first two attempts. The first download was again done with the known good memory module in the golden chassis and was successful, demonstrating that the boards had not been damaged and data had not been compromised by the removal of the conformal coating. The memory chips were removed from the good board and the accident chips were soldered in their place. However, when the good board with the accident chips was connected to the golden chassis the download failed in the same manner as it had in all previous attempts with the accident board, with a connection failure from the computer to the recorder.

With this result it became clear that the memory chips in the accident module were likely failed at the time of the accident, and no data could be extracted from them.

3.2.4. FDR Plots and Corresponding Tabular Data

N/A - no data was extracted from the accident memory module.