National Transportation Safety Board
Office of Highway Safety
Washington, DC 20594

HWY24MH005

VEHICLE RECORDERS

Group Chair's Factual Report

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A. CRASH INFORMATION

Location: Rushville, Schuyler County, Illinois
Date: March 11, 2024
Time: 11:29 a.m. CDT

B. VEHICLE RECORDERS GROUP

Group Chair	Jason Zeitler Senior Survival Factors Investigator NTSB
Group Member	Deven Chen Recorder Specialist NTSB
Group Member	Eric Gregson Technical Reconstructionist NTSB

C. CRASH SUMMARY

For a summary of the crash, refer to the *Crash Information and Summary Report*, which can be found in the NTSB docket for this investigation.

D. DETAILS OF THE INVESTIGATION

The Vehicle Recorders Group Chair's Factual report is a collection of information regarding the Ford chassis' damaged restraint control module (RCM), also known as an airbag control module (ACM), the exemplar validation method, and the procedure utilized to attempt to recover crash data stored in the subject module's microcontroller unit (MCU) which contained flash memory. The subject case involved a 2020 Ford Transit 350 chassis, with a Micro Bird school bus body (Micro Bird) that sustained extensive thermal damage during the collision sequence and events. As a result, traditional imaging methods utilized in the forensics community were unable to be utilized to image stored crash data. Advanced imaging methods were developed and utilized, which are outlined in this report. The subject MCU was too damaged to recover any digital crash data.

1.0 2020 Ford Transit 350 Chassis – Micro Bird School Bus Body

VIN:	1FDES6PG9LKA46677
Chassis Make:	Ford
Model:	Transit 350
Model Year:	2020
Body Make:	Micro Bird
ACM Part Number:	Unknown due to fire damage
Memory:	Integrated in Infineon MCU

As a result of damage from fire, water, and/or other physical trauma, electronic crash data recorded to an ACM's memory may be inaccessible by traditional imaging recovery methods. These methods include traditional imaging through a vehicle's diagnostic link connector (DLC), back-powering, or accessing the electronic crash data directly from the ACM using a direct-to-module methodology. When these traditional methods are unable to be successfully used for imaging an ACM due to damage present, an advanced procedure and methodology must be explored.

The Micro Bird sustained extensive damage during the collision sequence and events. The Micro Bird was equipped with an RCM, also referred to as an ACM, which had event data recording (EDR) capabilities. Most of the Micro Bird's ACM was destroyed during the post-collision fire. The remains of the Micro Bird's ACM consisted of a printed circuit board and one MCU, which was located amongst the vehicle debris and recovered by NTSB investigators, as observed in Figure 1.

The Micro Bird's ACM required a destructive chip-level forensics procedure, outlined in this report, to attempt to recover any potential crash data that the memory component of the ACM might have stored prior to the module being damaged.

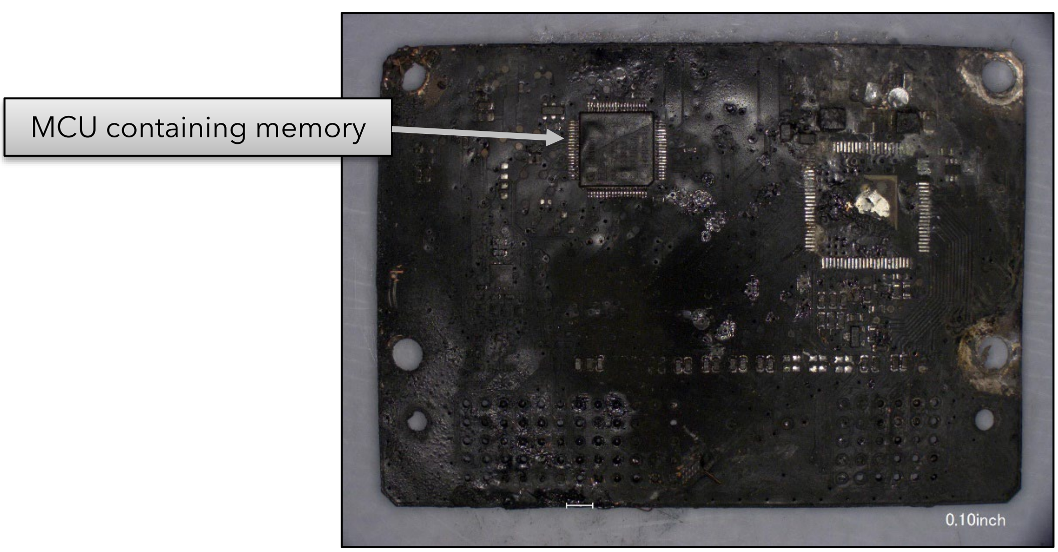

Figure 1: Micro Bird - Subject ACM

1.1 Details of the Exemplar Testing and Procedure Validation

The following exemplar testing, and procedures were performed as described and validated with the following peer-reviewed publication, lectures, and course:

1. Society of Automotive Engineers (SAE) Technical Paper 2021-01-0907[i]
2. 2021 IPTM Symposium on Traffic Safety Presentation[ii]
3. 2022 IPTM Symposium on Traffic Safety Presentation[iii]
4. 2024 IPTM Symposium on Traffic Safety Presentation[iv]
5. SAE Vehicle Crash Reconstruction: Principles and Technology[v]

Three exemplar ACMs were obtained by NTSB investigators. Each exemplar module contained the following manufacturer, part number, serial number, memory type, and events present:

Exemplar ACM 1

Manufacturer:	Ford Motor Company
Part Number:	LK4T-14B321-CE
Memory:	Integrated in Infineon MCU
Event(s):	No (new module)

Exemplar ACM 2

Manufacturer:	Ford Motor Company
Part Number:	LT1T-14B321-KA
Memory:	Integrated in Infineon MCU
Event(s):	No

Exemplar ACM 3

Manufacturer:	Ford Motor Company
Part Number:	LK4T-14B321-BE
Memory:	Integrated in Infineon MCU
Event(s):	Yes; Event Record 1

1.2 Exemplar Testing and Procedure Validation

Exemplar 1 (E1), Exemplar 2 (E2), and Exemplar 3 (E3) were utilized during the testing and procedure validation prior to installing the subject Micro Bird's MCU containing onboard memory. First, E1, E2, E3, and the subject Micro Bird ACM were labeled respectively using a unique color code identifier. The casing and printed circuit board (PCB) of E1 were labeled "E1" in red, and the orientation of its MCU was also marked in red. The casing and PCB of E2 were labeled "E2" in blue, and the orientation of its MCU was also marked in blue. The casing and PCB of E3 were labeled "E3" in green, and the orientation of its MCU was also marked in green. The orientation of the subject MCU was marked in purple. Next, E1, E2, and E3 were secured to the workstation using a clamp to prevent movement of the modules, prior to being imaged. E1, E2, and E3's original data were imaged using a benchtop download method using the most current available version of Bosch Crash Data Retrieval (CDR) software.

A Bosch CANPlus CDR interface with a serial to USB plug and power source, a clamp, a laptop with Bosch CDR software, a direct-to-module cable 823 (1699200428), and an ACM adapter (F-00K-108-387) were utilized. The exemplar vehicle information and notes were entered into the Bosch CDR software and the ACM was imaged. During the download process, three successful passes were observed prior to the data being saved to the local case folder. Power was disconnected from the CANPlus interface, and the exemplar ACM was unclamped. This procedure was successfully completed for all three exemplar ACMs.

E1, E2, and E3 were each disassembled and each of the respective integrated circuit boards were labeled with the unique identifiers that were previously used on the ACM casing. Using a stereo microscope, the characters located on the various chip components were examined until a memory device was located. The subject MCU, which functions as a restraint deployment logic and data storage processor was identified. To confirm that this component contained and stored all the crash data for this particular module and no secondary or tertiary memory device was utilized, destructive testing was performed. To accomplish this, the MCUs belonging to E1, E2, and E3 were removed, E3's MCU was reinstalled into E2, redownloaded, and the subsequent data was compared to the initial data downloaded from the respective module prior to the destructive testing.

Validating chip-level component swaps across modules of identical part numbers is a topic that has been validated in previous SAE literature and extensive cases.[i] The topic of component transfers across modules of slightly varying part numbers has been explored successfully in various lectures and during the initial research for the previously cited SAE technical paper.[i] Due to extensive thermal damage, the exact subject Micro Bird ACM was unknown. To validate the successful transfer of data across these slightly varying non-identical part numbers, further testing was required. The MCU belonging to E3 was installed into E2. The final product of E3's MCU installed into the non-identical E2 module can be observed in Figure 2.

Figure 2: Exemplar 3's MCU installed into Exemplar 2

Utilizing a benchtop download methodology, E2 containing the MCU belonging to E3 was imaged successfully. To validate the successful transfer of data across the non-identical modules, the data from the original download of E3 was compared to the data obtained from the download of E2 containing E3's MCU. It was expected that certain information contained in the CDR download reports would be different; date/time, user inputted description, DTCs at time of retrieval, key cycles, and the associated hexadecimal data. However, the overall data related to the stored crash events was expected to remain unchanged; System Status, Deployment Command Data, Pre-Crash Data -5 to 0 sec, and change in velocity (Delta-V) plots. [1]

When comparing the pre-crash data downloaded from E3 to the downloaded pre-crash data from E2 containing E3's MCU, the crash data was identical. This testing, along with prior literature and lectures, showed that data could be successfully transferred between ACM of slightly varying part numbers.

[1] With the exception of key cycles during download – System Status – as key cycles are expected to advance during the procedure.

1.3 Details of the Subject Procedure

Subject ACM

ACM Manufacturer:	Ford Motor Company
Part Number:	Unknown
Serial Number:	Unknown due to fire damage.
Memory:	Infineon MCU
Event(s):	Unknown – None recovered due to thermal damage

The following subject ACM testing and procedures were performed as described and validated with the peer-reviewed publications, lectures, and courses previously described in Section 1.1 of this report.

The subject Micro Bird ACM sustained extensive thermal damage as a result of the ensuing fire from the collision. The MCU installed in the subject ACM exhibited one large crack that traversed from the top-center of the MCU, to the lower-right, as observed in Figure 3. It was unknown if the visible crack penetrated the layers beyond the external casing of the MCU.

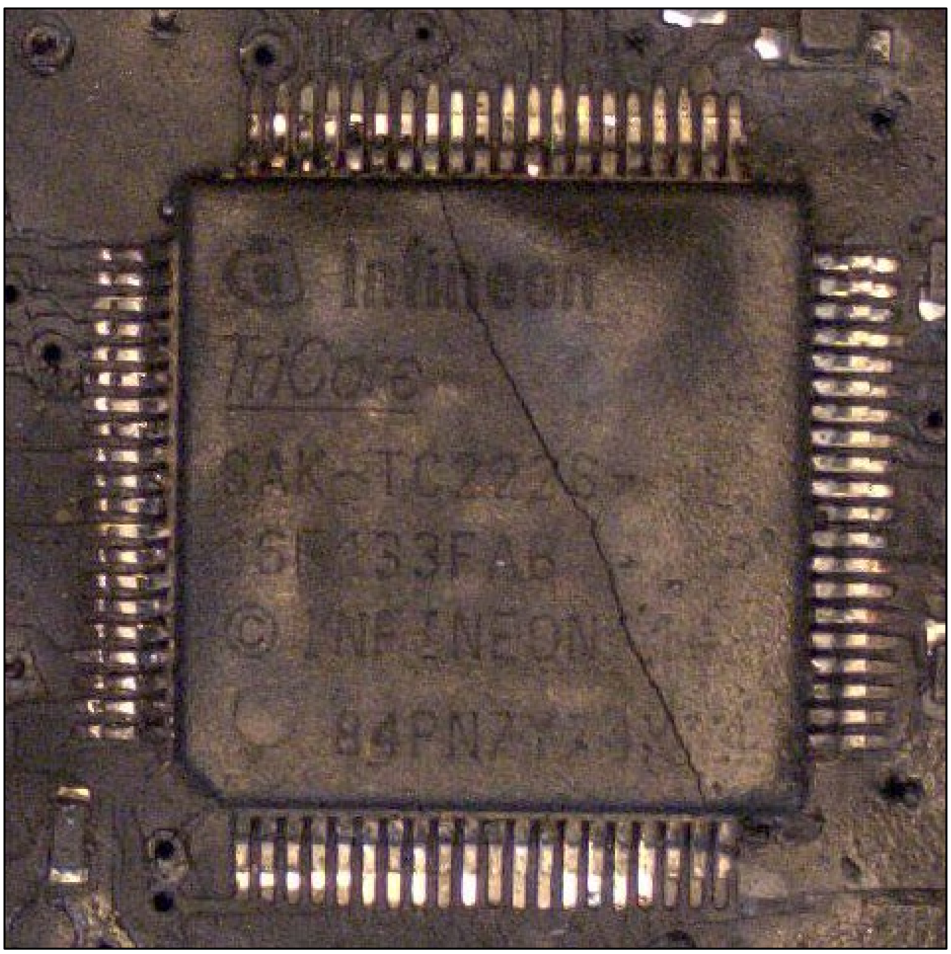

Figure 3: Micro Bird – Damaged subject MCU

X-ray imaging was conducted on the subject MCU. In addition to the visible crack identified in Figure 3, at least two additional cracks were located, as observed in Figure 4 and identified with orange arrows.

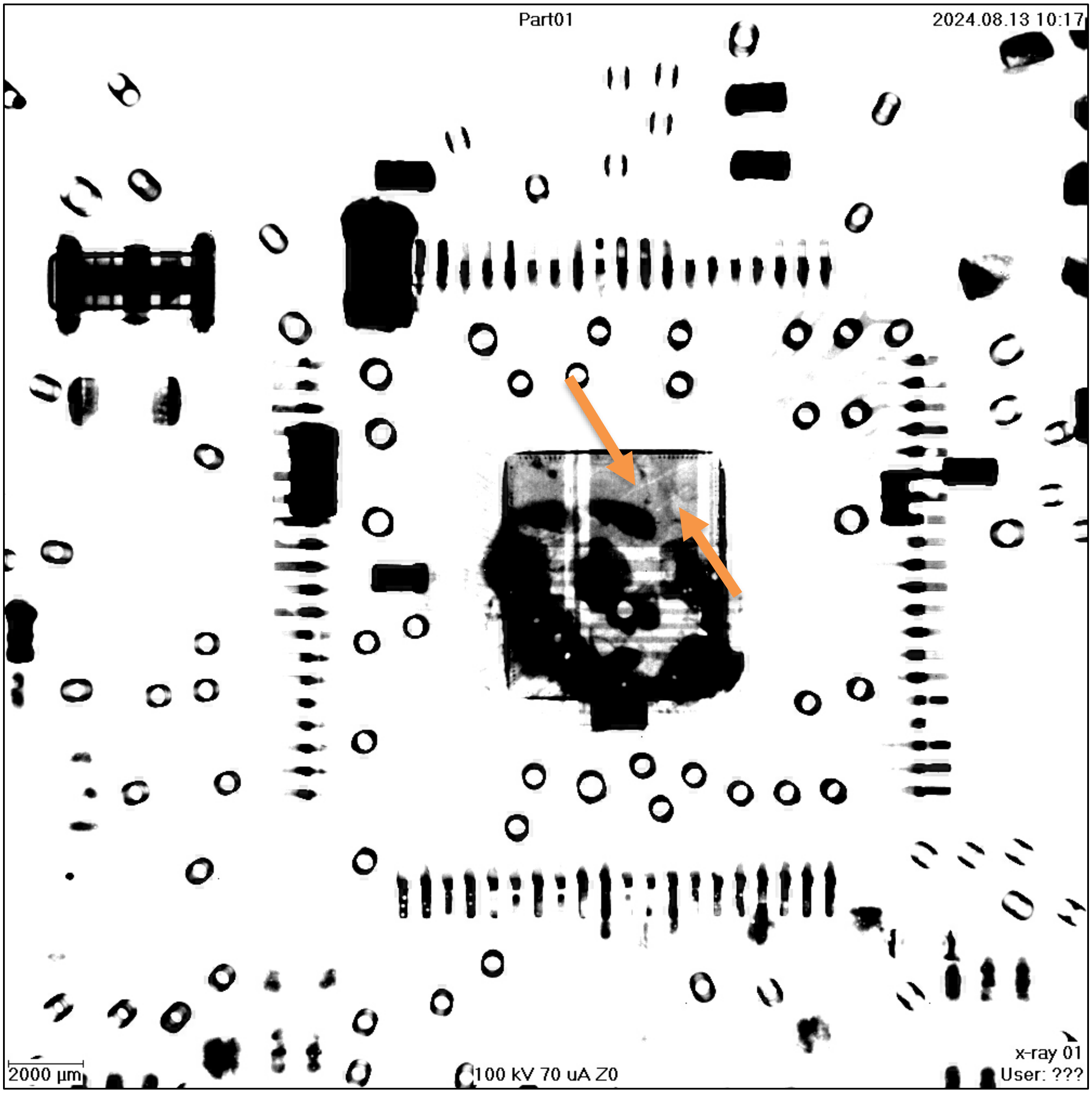

Figure 4: Micro Bird - Subject ACM x-ray Imaging

The subject MCU was removed from the board by applying heat until the MCU released, as observed in Figure 5.

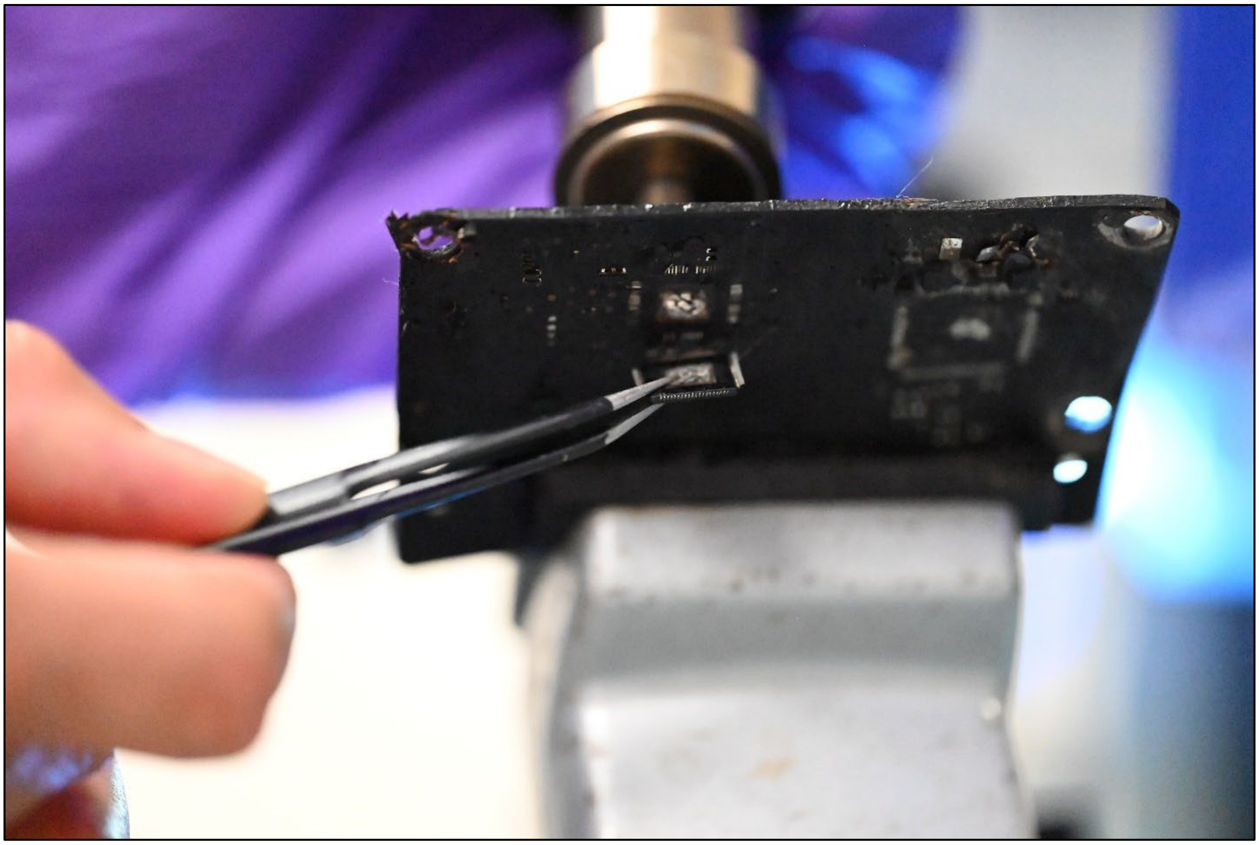

Figure 5: Micro Bird - MCU removal

The same methodology that was previously described and validated in Section 1.1 were performed on the subject MCU using E1. The subject MCU was removed from the damaged ACM and its orientation was labeled in purple, as observed in Figure 6.

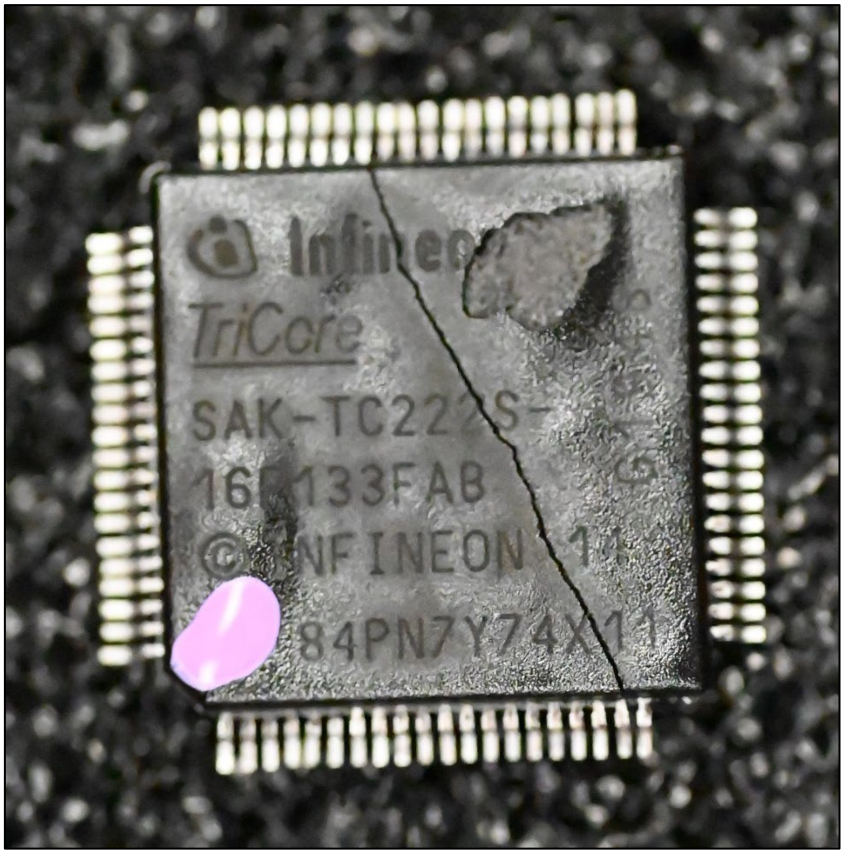

Figure 6: Micro Bird - MCU

The Micro Bird's MCU was installed into E1 utilizing heat, flux paste, solder, solder wick, and isopropyl alcohol. A Bosch CANPlus CDR interface with a serial to USB plug and power source, a clamp, a laptop, a direct-to-module cable 823 (1699200428), and an ACM adapter (F-00K-108-387) were utilized. The clamped E1 containing the subject MCU can be observed in Figure 7.

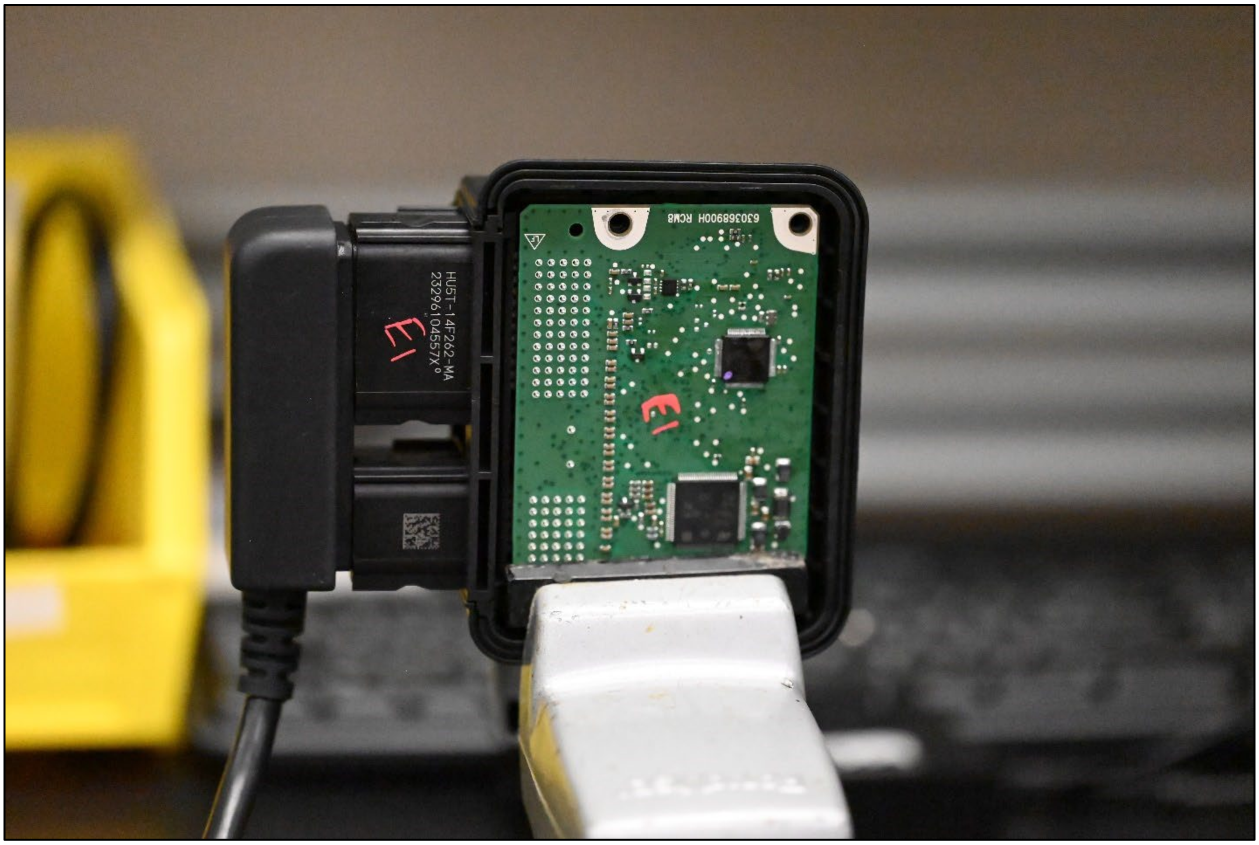

Figure 7: Exemplar 1 containing subject MCU

The subject vehicle information and notes were entered into the Bosch CDR software and attempts were made to image the ACM. Due to the various cracks that were determined to have penetrated beyond the layers of the MCU casing, no data was able to be retrieved from the subject MCU.

E. ATTACHMENTS

- None

Submitted by:

Jason Zeitler
Senior Survival Factors Investigator

[i] Zeitler, J., Et al., "Validation of EEPROM Chip Removal and Reinstallation for Retrieval of Electronic Crash Data - Destructive and Non-Destructive Methods," SAE Technical Paper 2021-01-0907, 2021, https://doi.org/10.4271/2021-01-0907.

[ii] Zeitler, J. (2021, June). 2021 IPTM Symposium on Traffic Safety. Airbag Control Module EEPROM Chip Swaps for the Retrieval of Crash Data – Destructive and Non-Destructive Methods. Orlando, Florida: Institute of Police Technology and Management (IPTM).

[iii] Zeitler, J. (2022, June). 2022 IPTM Symposium on Traffic Safety. Chip-Level Forensics: Recovering Crash Data from Burnt and Damaged Airbag Control Modules and Event Data Recorders. Orlando, Florida: Institute of Police Technology and Management (IPTM).

[iv] Zeitler, J. (2024, June). 2024 IPTM Symposium on Traffic Safety. Recovering Crash Data from Burnt and Damaged EDRs. Orlando, Florida: Institute of Police Technology and Management (IPTM).

[v] Zeitler, J. (2020-2022). SAE Vehicle Crash Reconstruction: Principles and Technology. Course 1728, Module 5 – Event Data Recorders.