

**NATIONAL TRANSPORTATION SAFETY BOARD**  
Vehicle Recorder Division

March 23, 2022

**Flight Management Computer & Maintenance Data Computer**

**Specialist's Factual Report**  
**By Kyle Garner**

**1. EVENT**

Location: Truckee, California  
Date: July 26, 2021  
Aircraft: Bombardier Inc. CL-600-2B16  
Registration: N605TR  
NTSB Number: WPR21FA286

**2. GROUP**

A group was not convened.

**3. DETAILS OF INVESTIGATION**

The National Transportation Safety Board (NTSB) Vehicle Recorder Division received the Integrated Avionics Processing System (IAPS) cage recovered from the aircraft wreckage. The IAPS cage contained multiple line-replaceable units (LRUs) including the flight control computers, flight management computers, the maintenance data computer, and others. Two modules installed in the IAPS cage were of interest and are discussed in this report:

Model Name/Number: **FMC-6000**  
Part Number: **822-0868-089**  
Serial Number: **Unknown<sup>1</sup>, 1101, 1389 (3x units in total)**

Model Name/Number: **MDC-3110**  
Part Number: **822-1987-006**  
Serial Number: **Unknown<sup>1</sup>**

**3.1. FMC-6000 Description**

The FMC is part of the overall Flight Management System (FMS), which provides enroute, terminal, and non-precision approach navigation. Each FMC receives data from

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<sup>1</sup> The serial number of the FMC and MDC was stamped on a latch. The latch for the MDC and one of the FMC units was not recovered in the wreckage.

both the left and right avionics systems. A Control Display Unit (CDU) is the primary interface between the pilot and the FMS. Three FMC units were installed on the event aircraft and were physically located in the IAPS cage.

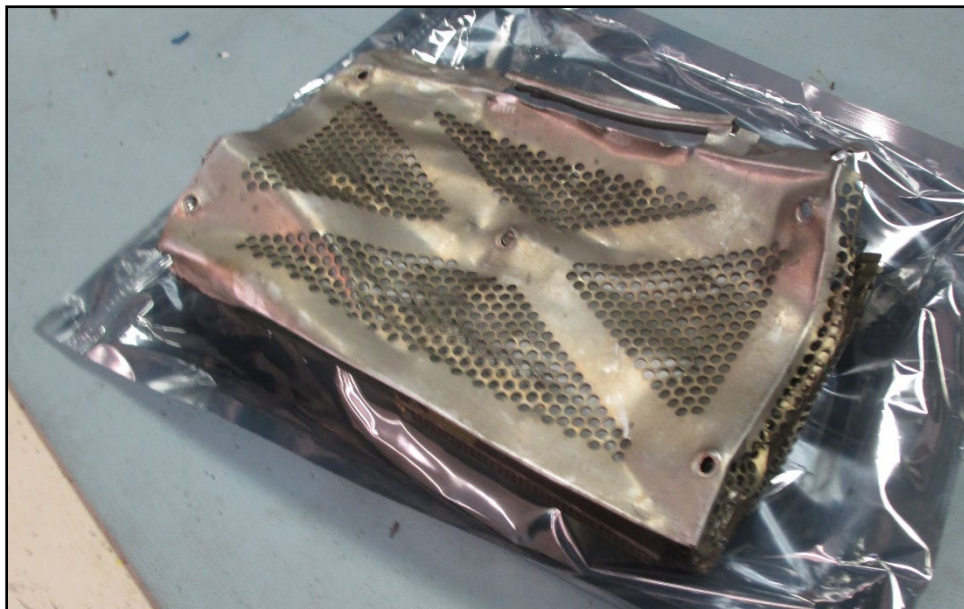
The FMC uses battery-backed static random access memory (SRAM)<sup>2</sup> to retain aircraft performance information, v-speeds, flight plans, navigation data, fault codes, and a real-time clock when no power is applied to the avionics bus.

### **3.1.1. FMC-6000 Condition and Data Recovery**

Two of the FMC units ("FMC 2" and "FMC 3") arrived at the Vehicle Recorder Division laboratory still contained within the IAPS cage. The third FMC unit ("FMC 1") was found ejected from the IAPS cage in the wreckage and shipped separately. The IAPS cage, with FMC 2 and 3 still installed, and FMC 1 was shipped to Collins Aerospace for further examination.

Upon arrival at Collins Aerospace in Cedar Rapids, Iowa, FMC 2 and FMC 3 were removed from the IAPS cage and all three FMCs were inspected for damage by a Collins Aerospace technician with oversight by the NTSB.

An external inspection revealed significant impact damage to all three FMC units, as shown in Figure 1, Figure 2, and Figure 3. Foreign object debris (FOD) was also audible when the units were examined.



**Figure 1. FMC 1, as received.**

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<sup>2</sup> SRAM is a type of volatile memory (i.e. data is lost when power is removed).

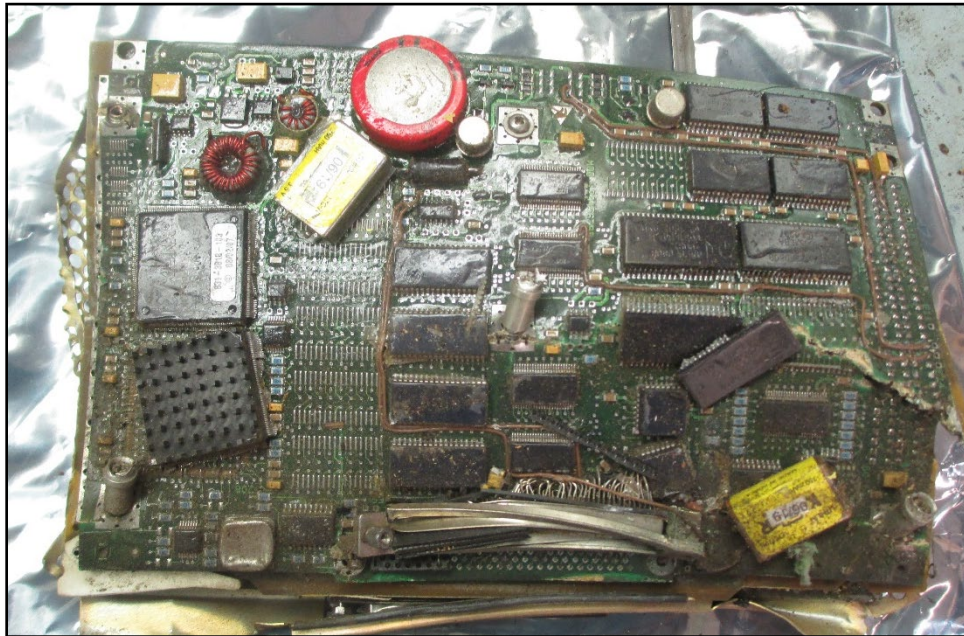


**Figure 2. FMC 2, removed from IAPS cage.**



**Figure 3. FMC 3, removed from IAPS cage.**

The covers on the FMCs were removed and the FOD was noted to be the SRAM batteries that had separated from the circuit cards. In addition, the backplane connector used to interface with the test equipment was damaged on all three units. Damage to FMC 2, with the cover removed, is shown in Figure 4.



**Figure 4. FMC 2 damage, with cover removed. Damage to FMC 1 and FMC 3 was similar.**

Due to the damage to the backplane connector and the separation of the SRAM batteries from the circuit cards, it was determined that data from the FMCs were not recoverable.

### **3.1.2. FMC-6000 Data Description**

All three FMCs had damage from the impact that inhibited the download of data, thus, no data relevant to the event was recovered.

### **3.2. MDC-3110 Description**

The MDC assists the flight crew and/or maintenance personnel in detecting and troubleshooting faults in other LRUs. The MDC continuously monitors other LRUs and if a fault is detected, the MDC displays this information on the multi-function displays (MFD).

The MDC stores the history of the fault data (up to 300 total) in non-volatile memory (NVM)<sup>3</sup> for download to a disk or USB drive. The MDC also provides functional capabilities to set the MDC's internal clock, set the aircraft's identification (tail number), and view LRU diagnostic data. The MDC is physically located in the IAPS cage.

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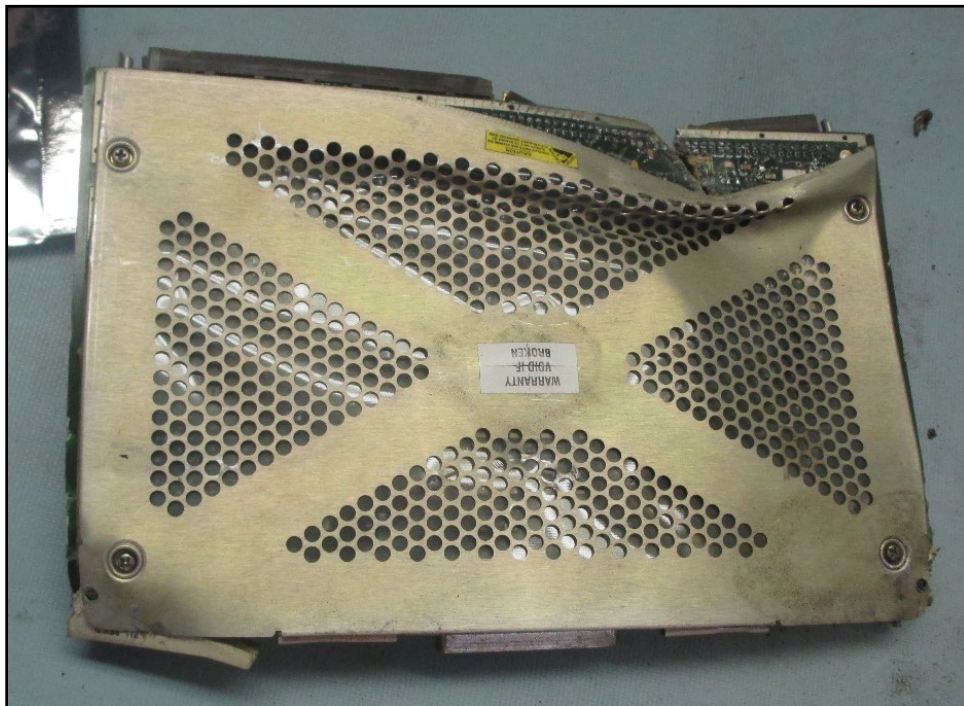
<sup>3</sup> NVM is semiconductor memory that does not require external power for data retention.

### 3.2.1. MDC-3110 Condition and Data Recovery

The MDC arrived at the Vehicle Recorder Division laboratory still contained within the IAPS cage. The IAPS cage, with the MDC still installed, was shipped to Collins Aerospace for further examination.

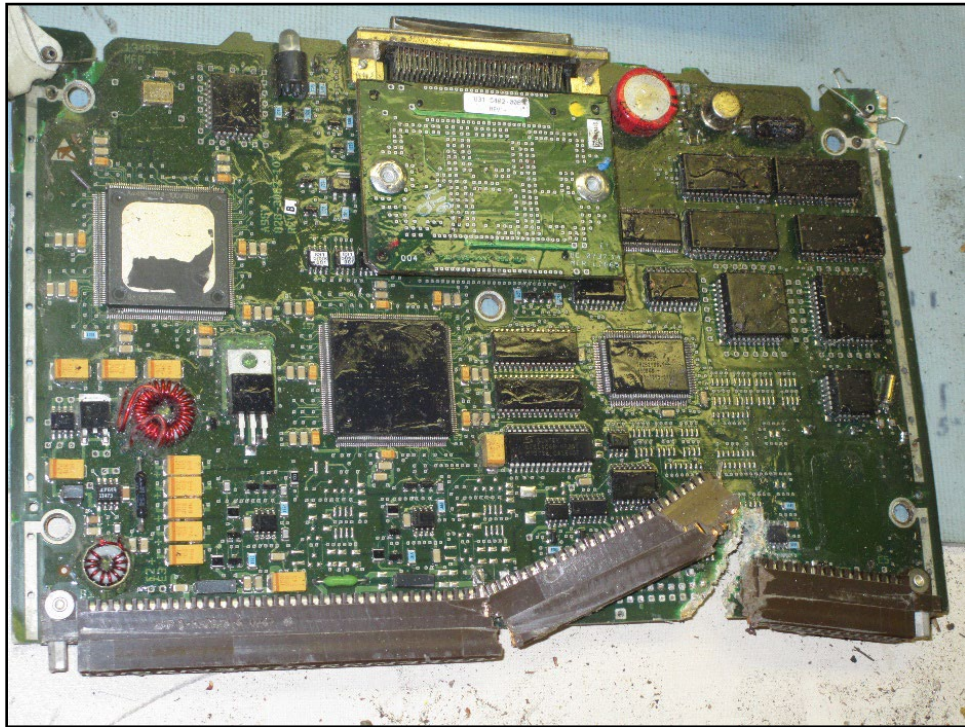
Upon arrival at Collins Aerospace in Cedar Rapids, Iowa, the MDC was removed from the IAPS cage and inspected for damage by a Collins Aerospace technician with oversight by the NTSB.

An external inspection revealed significant impact damage to the MDC cover and main connector, as shown in Figure 5.

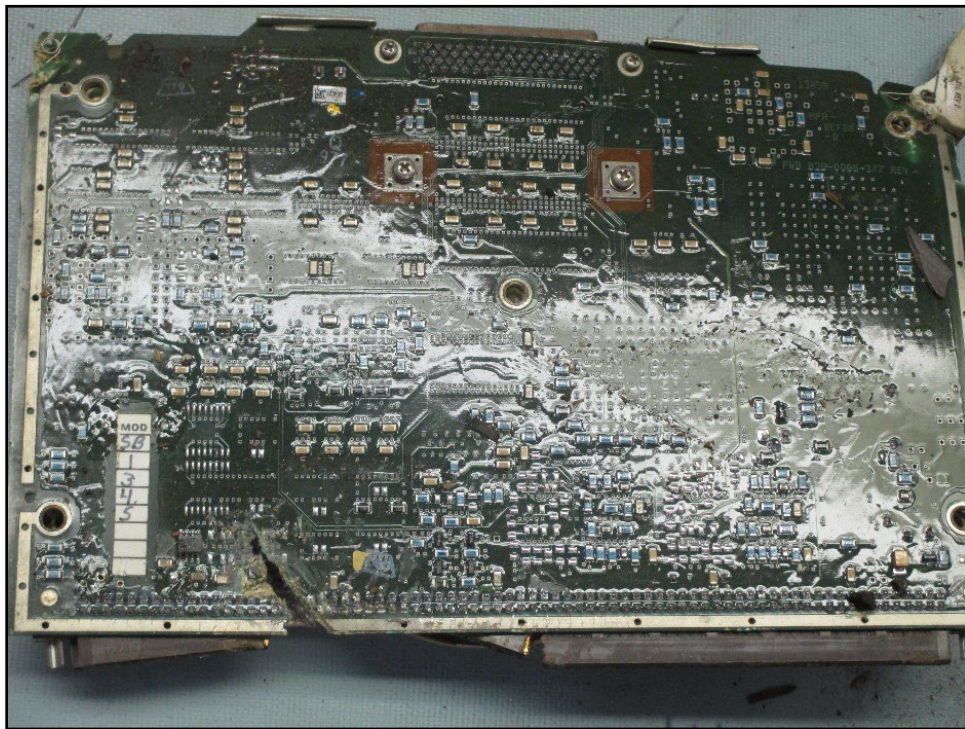


**Figure 5. MDC, removed from IAPS cage.**

FOD was also audible when the unit was removed from the cage. The cover was removed and the FOD was noted to be the processor's heatsink and battery. An approximately 2-inch long gash was also visible on the circuit board in the area where the main connector was damaged. A photograph of the top and bottom of the MDC, with the cover removed, is shown in Figure 6 and Figure 7.



**Figure 6. Top of MDC, cover removed.**



**Figure 7. Bottom of MDC, cover removed.**

It was determined that the MDC could not be downloaded as-is due to the damage to the main connector and circuit board.

An exemplar MDC-3110 with the same circuit card assembly was located and converted to the same top-level MDC assembly as the damaged unit. The exemplar unit was installed in an MDC test rig to ensure it was in working order. The NVM chip on the damaged MDC was located, removed, and installed on the exemplar MDC<sup>4</sup>.

### 3.2.2. MDC-3110 Data Description

The exemplar MDC with the damaged MDC's NVM was placed into the MDC test rig, which was configured to be read-only to ensure that the NVM could not be overwritten. The test rig was powered on and the MDC booted normally. The aircraft identification, "HBJFA"<sup>5</sup>, was visible on the screen. All available log files were downloaded, which included:

HBJFA0.CFM	Current Faults
HBJFA0.CSD	Configuration Data
HBJFA0.CSM	Current Service Messages
HBJFA0.EED	Engine Exceedances
HBJFA0.ETM	Engine Trend
HBJFA0.FLS	Flight Leg Summary
HBJFA0.FMH	Fault History
HBJFA0.SMH	Service Message History
HBJFA0.SP	System Parameters

The log files were reviewed and were either blank or contained invalid data, thus no data relevant to the event were recovered.

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<sup>4</sup> The manufacturer stated that they had previous experience swapping a NVM chip on an MDC and the previous attempt had not been successful in recovering any relevant data. However, given the damage to the event MDC circuit board and connector, it was decided to make another attempt.

<sup>5</sup> The event aircraft, N605TR, was previously registered as HB-JFA from 2012 to 2016.