

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

Airworthiness Group Chairman's Factual Report

July 25, 2022

A. ACCIDENT WPR21FA286

Location: Truckee, California
Date: July 26, 2021
Time: About 1318 Local Time
Aircraft: Bombardier Inc., CL-600-2B16 (604 Variant), N605TR

B. GROUP

Chairman: Tom Jacky
National Transportation Safety Board
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Technical Advisor: Michael Lemay
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C. SUMMARY

On July 26, 2021, about 1318 pacific daylight time, a Bombardier Inc., CL-600-2B16 airplane, N605TR, was destroyed when it was involved in an accident near Truckee-Tahoe Airport (TRK), Truckee, California. The pilot, co-pilot and 4 passengers were fatally injured. The airplane was operated as a Title 14 Code of Federal Regulations Part 91 personal flight.

The investigation focused on airplane weights stored in the airplane's flight management system (FMS). As part of the investigation, National Transportation

Safety Board's (NTSB) Vehicle Recorder Division received multiple line-replaceable units (LRUs) removed from the airplane wreckage, including the following modules:

1. Flight Management Computer (FMC), Number 1 Position
Model Name/Number: FMC-6000
Manufacturer: Collins Aerospace
Part Number: 822-0868-089
Serial Number: 23NNN
2. Flight Management Computer (FMC), Number 2 Position
Model Name/Number: FMC-6000
Manufacturer: Collins Aerospace
Part Number: 822-0868-089
Serial Number: 1101
3. Flight Management Computer (FMC), Number 3 Position
Model Name/Number: FMC-6000
Manufacturer: Collins Aerospace
Part Number: 822-0868-089
Serial Number: 1389 (three units in total)
4. Maintenance Diagnostic Computer (MDC)
Model Name/Number: MDC-3110
Manufacturer: Collins Aerospace
Part Number: 822-1987-006
Serial Number: Unknown

The investigation determined that the airplane basic operating weight (BOW) would have defaulted to 24,000 pounds in the absence of any other weight entered into the flight management system.

As the maintenance provider indicated that they did not enter an airplane weight (and did not have an airplane weight value provided to them), the FMCs defaulted to a weight of 24,000 pounds.

D. DETAILS OF INVESTIGATION

1. Previous Examination of FMC-6000 Units

On December 14, 2021, the NTSB conducted an examination of the three FMC-6000 units removed from the accident airplane at the Collins Aerospace facility in Cedar Rapids, Iowa. Collins Aerospace (previously known as Rockwell Collins) was the manufacturer of the FMC-6000.

The examination of the FMC-6000 units determined that the batteries were dislodged from the cards, therefore the unit's static random-access memory (SRAM) was lost due to the removal of battery back-up power. All three FMCs had damage from the impact that inhibited the download of data, thus, no data relevant to the event was recovered. Due to the damage to the units and the separation of the batteries from the circuit cards, it was determined that there was no FMC data to recover.

The examination confirmed the FMC 2 and FMC 3 serial numbers with the numbers provided by the airplane's maintenance records. The serial numbers of the FMC and MDC units were stamped on a latch. The latch for FMC 1 was missing and not recovered in the wreckage. Therefore, the serial number for FMC 1 (23NNN) was determined (by the FMC manufacturer) from the part and serial number of the internal circuit card assemblies. This serial number was later confirmed by maintenance documentation (See Section 2.1.3, "Examination of Maintenance Records and Actions by C&L Aviation Services Regarding the Three FMC 6000 Units").

For more information regarding the NTSB's examination of the airplane's FMCs and integrated avionics processing system (IAPS), please refer to the [Flight Management Computer & Maintenance Data Computer - Specialist's Factual Report](#), in the public docket to this investigation.

2. [Flight Management System](#)

2.1 Description of Flight Management System

The airplane's flight management system (FMS) is a dual system with an optional third system. The FMS performs navigation functions, radio tuning, and calculates engine performance parameters. The FMS supplies lateral and vertical navigation guidance and can be coupled to the automatic flight control system (AFCS). The outputs are displayed on the control display units (CDU) and on the electronic flight instrument system (EFIS).

The three CDUs installed on the center console in the flight deck to were used to interface with their respective FMS via the FMC. The CDUs allowed the flight crew to input, modify, and execute flight plans as well as calculate aircraft performance. In addition, pages on the CDU allowed the flight crew to enter airplane and fuel weights into the FMS.

The FMS was part of the airplane's integrated avionics processing system (IAPS), the focal point of information flow for the airplane. The IAPS also contained the flight control computers (FCCs) and maintenance diagnostic computer (MDC). The airplane's Electronic Flight Instrument System (EFIS) interfaced with the FMS, Air Data System, and Inertial Reference System to provide information for display on the flight instruments.

The three FMC units were installed in the IAPS cage, which was in the underfloor avionics equipment bay.

The FMC-6000 uses battery-backed, static random-access memory (SRAM) to retain aircraft performance information, flight plans, navigation data, fault codes, and a real-time clock¹. Collins Aerospace indicated that, if the FMC-6000 battery is removed, the information stored in memory is lost.

The FMC re-installation task from the Bombardier AMM listed three different methods to install the necessary databases. Depending on the serial number of the CL-605 aircraft, the task details the use of the following tools to install the databases:

- I. Data Base Unit (DBU), an installed data loader, mounted either in an avionics bay or flight deck.
- II. CPAS-3000 (Collins Portable Access System), a software application, run from an external computer and connected to the airplane's maintenance panel via an Ethernet cable, provided media download capabilities.
- III. PCD-3000 (Personal Computer Data Loading System) is another software application run on a personal computer that provided media download capabilities. The external computer is connected to the airplane through a PCMCIA² interface card, inserted in the laptop, and a cable that connects the PCMCIA card to the DBU.

For more description and information regarding the airplane's FMS, EFIS, and other airplane systems, please refer to the Operational Factors Group Chairman's Factual Report, Chapter 10.0, "Relevant Systems", in the public docket to this investigation.

2.2 Bombardier Aircraft Maintenance Manual Tasks Related to FMC-6000 Battery Replacement and Subsequent Return to Service

According to Bombardier, for the airplane serial number of the accident airplane, the maintenance tasks/steps defined in the CL-605 Aircraft Maintenance Manual (AMM) regarding the FMC-6000 battery replacement and return to service actions are as follows:

1. **TASK 22-12-16-000-801**, "Removal of the Flight Management Computer", details the process to remove the FMC(s) from the airplane's IAPS cage.

¹ Collins Aerospace indicated that newer FMC-6000 models use nonvolatile memory and do not require battery back-up power.

² Personal Computer Memory Card International Association Card

2. **TASK 22-12-16-960-801**, "Discard of the Flight Management Computer Battery", is the task to replace/discard the FMC battery. The task details how to remove the FMC from the IAPS Cage and then send it to a Collins Aerospace (former Rockwell Collins) Service Center for battery replacement. This task is prompted by optional maintenance listed in the Maintenance Planning Document, Task 22-12-16-301.

As part of the battery replacement servicing, Collins Aerospace disassembles, visually inspects, cleans, reassembles, and then tests the FMCs prior to customer return.

3. **TASK 22-12-16-400-801**, "Installation of the Flight Management Computer", details the re-installation of the FMC(s) into the airplane. After the FMC is re-installed into the IAPS Cage, it is necessary to restore information into its memory; the appropriate databases need to be re-installed. Procedure Step E. (12) of the task lists all the databases that are required to be loaded into each FMC following installation. In addition, at the bottom of Page 407 is the following note: "Make sure that the default values and basic operating weight (BOW) value are appropriate for the aircraft." See excerpt below, Figure 1.

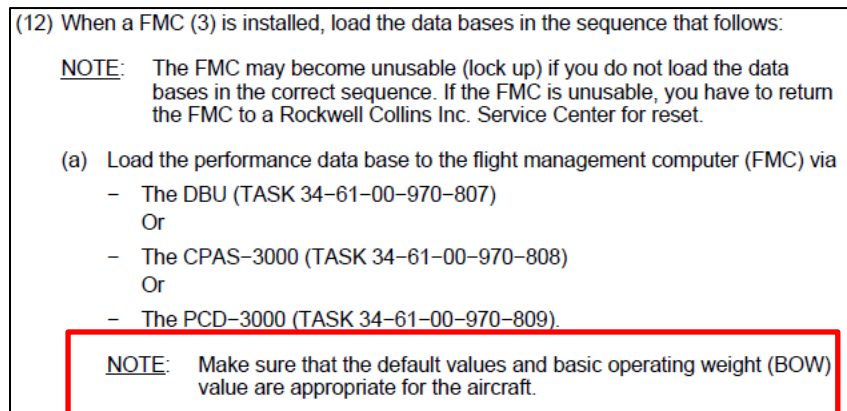


Figure 1 - Excerpt from Maintenance Task, With Basic Operating Weight Note in Red Box (Courtesy of Bombardier Aircraft)

The following databases were required to be downloaded into the FMC-6000 units:

- i. Navigation Data Base
- ii. V-Speed Data Base
- iii. Performance Data Base
- iv. Route or Pilot's Way Point Data Base

Note that, for the above databases, the airplane's BOW directly affects the output values from the Performance and V-Speed Data Bases.

The following tasks detail how to load the data bases into the FMC(s) by use of the CPAS-3000:

4. **TASK 34-61-00-970-802**, "Load the Navigation Data Base to the Flight Management Computer (FMC) via the CPAS-3000"
5. **TASK 34-61-00-970-805**, "Load the V-Speed Data Base to the Flight Management Computer (FMC) via the CPAS-3000"
6. **TASK 34-61-00-970-808**, "Load the Performance Data Base to the Flight Management Computer (FMC) via the CPAS-3000"

Each of the CPAS-3000 Data Base download tasks prompt the user to properly download the data bases into the FMC, and each task has the note regarding appropriate BOW entries.

2.3 Examination of Maintenance Records and Actions by C&L Aviation Services Regarding the Three FMC 6000 Units

C&L Aviation Services in Bangor, Maine, performed maintenance on the airplane during 2020. The company provided the NTSB with the records of the maintenance as part of the investigation.

On May 6, 2020, the three FMC-6000 units were removed from the airplane as part of a maintenance task to replace their batteries. The task was part of optional maintenance detailed in the Maintenance Planning Document, Task 22-12-16-301. The FMC-6000s were removed per the C&L Maintenance Card for Work Package #A1144, Card 11. See Attachment 1.

As part of the maintenance action, the removed cards were sent to the Collins Aerospace facility in Mexicali, Mexico. The FMC-6000 batteries were replaced at the Mexicali Collins facility. Each of the three FMC-6000 units were certified for return to service. See Attachment 2.

According to C&L maintenance paperwork, the FMC-6000 units were received from Collins and then re-installed into the airplane, each in their original slots. This action was dated July 24, 2020. See Attachment 1.

After re-installation of the FMCs, C&L installed the required databases into the units. C&L used a CPAS-3000³ to load the required databases into the three FMCs, including the following databases:

³ The accident airplane was not equipped with a DBU.

- V-Speeds (Part Number 815-9174-001)
- Performance (Part Number 815-9079-001)

In an email to the Group Chairman, C&L indicated that they did not enter an airplane weight into the FMC-6000s. C&L also stated that they were not provided an airplane weight by the operator, nor was weighing the airplane part of the maintenance performed on the airplane⁴.

2.4 FMC Default Basic Operating Weight Determination

The NTSB requested that Collins Aerospace verify the default basic operating weight (BOW) used for the CL-605, using the aircraft performance data base downloaded from a CPAS-3000.

Collins Aerospace conducted a test using their FMC-6000 and CDU Test Bench and Simulator. First, after installing an FMC-6000 card into the simulator, they simulated a removal of the battery by clearing all information from the FMC card. Checking the weight entry on the ACFT PERF INIT page of the FMC, Collins confirmed that, after clearing the FMC memory, the BOW is cleared (zero weight). See Figure 2.

⁴ Bombardier indicated that, in the absence of a weight and balance report, one way to "Make sure that the default values and basic operating weight (BOW) value are appropriate for the aircraft" would be to use the FMS in the aircraft to display the default values and BOW and note them prior to removing the FMCs; these values can then be re-entered upon re-installation of the FMCs.



Figure 2 - After clearing the FMC the BOW is cleared as shown. BOW value is boxed in red.
(Photograph courtesy of Collins Aerospace)

After re-installing the appropriate performance databases, and without any additional weight entries by the user, Collins confirmed that the BOW reverted to 24,000 pounds. See Figure 3.



Figure 3 - After re-installing the performance databases, the default BOW is 24,000 pounds, as shown in red box. (Photograph courtesy of Collins Aerospace)

Collins also confirmed that the installation of the performance database does not prompt the user/installer to enter an airplane weight (for example, a designed stop in the software download requiring the user to enter a value for the BOW).

2.5 Previous Calculation of Airplane's Weight

Prior to being brought onto the U.S. registry, the airplane was previously registered in Malta (registration 9H-VPB). In an email to the group chairman, a previous maintenance provider shared a weight report, dated 14 February 2020, that listed the airplane's weight (Total Net Mass) as averaged between 26,242.00 and 26,244.84 pounds.

3. Airplane Powerplant Information from FDR Data

Discussion and review of the FDR data with GE Aviation Commercial Flight Safety personnel determined the following observations:

- During the 45 minutes of steady cruise flight at about 37,000 ft and 250 knots airspeed both engine's fan speeds (N1) and core speeds (N2) remained stable and matched with each other at about 90% speed.

- Also, during the 45 minutes of steady cruise flight, both engine's inter turbine temps (ITT) and fuel flows remained stable and matched with each other.
- During the 30-minute descent and approach to landing, both engine's fan speeds, core speeds, ITT's and fuel flows continued to remain matched with each other.
- Also, during the 30-minute descent and approach to landing, both engine's fan and core speeds also increased and decreased normally in response to the changes in thrust demand arising from aircraft altitude, airspeed and directional changes.
- During the final 6 seconds before the end of the FDR recording, both engines were seen to start increasing thrust from a low setting, as evidenced by accelerating fan and core speeds.
- The thrust increase began at about the same time as the initial stick shaker and stick pusher activation.
- Based on the FDR data, GE Aviation indicated that the CF34-3B engines were operating normally throughout the accident flight.

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