NTSB Identification: ERA16LA082
Accident occurred January 6, 2016 in Savannah, GA
Aircraft: Pilatus PC-12NG, Registration: N978AF

Introduction:

On January 6, 2016, about 0830 Eastern Standard Time, a Pilatus PC-12/47E, N978AF, operated by PlaneSense, Inc., was substantially damaged during a forced landing while taking off from Savannah/Hilton Head International Airport (SAV), Savannah, Georgia. The captain and first officer sustained minor injuries. Visual meteorological conditions prevailed, and an instrument flight rules flight plan had been filed for the flight to Blue Grass Airport (LEX), Lexington, Kentucky. The positioning flight was operated under the provisions of 14 Code of Federal Regulations Part 91.

According to the responding Federal Aviation Administration (FAA) inspector, the captain stated to him that the first officer was flying, and that they were cleared to take off from runway 1. Power was applied, and throughout the takeoff roll and initial climb, all instruments were "normal." The captain then saw a "low torque CAS message," and the first officer said to declare an emergency. The captain checked that the landing gear were down, and the first officer turned the airplane left, toward open ground. The airplane then made "what appeared to be a normal landing" and appeared as though it would roll to a stop, but then encountered a drainage ditch.

The first officer added that the takeoff from runway 1 utilized the runway's full length, and that after a positive rate of climb, there was a "DING DING" with a "RED CAS" warning for torque. He also noticed that the actual torque at that time was 5.3 psi, while calculated torque was 43.3 psi. The first officer pushed the airplane's nose down, and after turning the airplane left and landing, braked "hard" before the airplane struck the ditch. After the crew egressed through the exit door, they noticed the airplane was on fire.

Honeywell was requested by the National Transportation Safety Board (NTSB) to perform a download of stored data from the dual channel Custom Input/Output (CSIO) module (P/N: 7036333-1906, S/N: 14091426) as well as a complete functional check of the unit. The CSIO was previously installed into the Modular Avionics Unit (MAU) of a Primus Apex system in the accident aircraft.

The CSIO module was shipped to the Honeywell service center located at [redacted] Wichita, Kansas where it was safely secured and locked until the date of the download and testing. The download and testing of the CSIO module was performed on May 25, 2016 at the same Honeywell service center where the unit had been stored. Government oversight of the download and testing was provided by a Principal Avionics Inspector with the FAA from their Wichita FSDO.

The dual channel (CSIO) module provides the primary interface to the aircraft-unique or 'custom' aircraft I/O. In the Pilatus PC-12NG, the CSIO module is installed into the Modular Avionics Unit (MAU) in slots 3 and 4. The CSIO module salient points are summarized as follows:

- Digital Engine Operating System (DEOS) based software.
- Dual wide (1.6 inches) module.
- Each channel (Channel A and B) includes a full functionality BIC backplane interface.
- Four front mounted D-Sub connectors.

<u>Download/Test Procedure and Observations</u>

1. The CSIO module was received in a standard Apex module shipping box. (Figure 1)
2. The CSIO module was removed from its protective Electro Static Discharge (ESD) bubble wrapped bag. (Figure 2)
3. A physical Inspection, including the use of a black light, was performed in order to look for any possible sheared components or damaged connectors (Figure 3).
    a. A burned smell, typical of burned electronics, was present with the unit. The source of the smell could not be determined.
    b. The CSIO module appeared to be undamaged.
4. The CSIO module was then installed into a test stand in order to download the stored Non-Volatile Memory (NVM) information out of the unit. (Figure 4). The following procedure was used for downloading as well as the data that was gathered.
    a. Power up channel A in DEOS and check for module communication (aka "PING"). Module communication was confirmed with a positive "Ping" return response.
    b. Initiate a Telnet session to the CSIO's channel A and check for Power-up Built In Test (PBIT) Faults. No PBIT faults were present.
    c. Perform a download of the fault history from the channel A unit. The download was completed successfully. (See data file "na_14091426a_apex_fault_history.pb1")
    d. Perform a download of the channel A EEProm which contains the PN and SN for the unit. The download was completed successfully. (See data file "na_14091426a_apex_allee.fil")
    e. Power up channel B in DEOS and check for module communication (aka "PING"). Module communication was confirmed with a positive "Ping" return response.
    f. Initiate a Telnet session to the CSIO's channel B and check for PBIT Faults. No PBIT faults were present.
    g. Perform a download of the fault history from the channel B unit. The download was completed successfully. (See data file "na_14091426b_apex_fault_history.pb1")

   h. Perform a download of the channel B EEProm which contains the PN and SN for the unit. The download was completed successfully. (See data file "na_14091426b_apex_allee.fil")
5. After the NVM downloads were completed, the Hardware Built In Test (Hbit) operating system was loaded to both channels of the CSIO on the JTAG Hbit loading fixture using the respective JTAG port for each CSIO (Figure 5). The Hbit software is required for testing purposes which was to occur in the next steps.
6. The CSIO was then placed into a Vector Test Platform for automated testing. (Figure 6)
7. The end item test (IT7036333-1902 Rev J) was run to the Apex test scenario (MT7036333-102, Rev F). (See data file "APEX Cust I_O in A13.txt" for test results).
8. After the end item test was completed, the unit was disassembled for further inspection.
9. A small amount of debris was identified on a couple of pins of the unit, internal to the CSIO (Figure 7). The source of the debris was unable to be determined. Testing was not performed in order to determine the composition of the debris. The debris appeared to be indicative of a corrosion/mold growth.
10. The CSIO module was left unassembled, carefully packaged, and placed back into the original shipping container for return.

<u>Test Results:</u>

NOTE: The following references to connections in the aircraft are based on information obtained from the "Engineering Bulletin for the Installation of the APEX Avionics System in the Pilatus PC12 Aircraft" (EB7037243 Rev R).

- A total of 18 failures were noted during the testing.
- 12 failures were associated with discrete outs from the channel B unit. Those were:
  - Discrete out Ground/Open – MAU(3/4)J3, Pin 1
    - Value read = 2.8V / Value expected = 2.0V
    - This connection is not connected in the aircraft
  - Discrete out Ground/Open – MAU(3/4)J3, Pin 2
    - Value read = 2.3V / Value expected = 2.0V
    - This connection is not connected in the aircraft
  - Discrete out Ground/Open – MAU(3/4)J3, Pin 3
    - Value read = 3.6V / Value expected = 2.0V]
    - Value read = 20.39V / Value expected = 23.24V to 28.0V
    - Value read = 20.46V / Value expected = 23.24V to 28.0V
    - This connection is not connected in the aircraft
  - Discrete out Ground/Open – MAU(3/4)J3, Pin 4
    - Value read = 2.6V / Value expected = 2.0V
    - Value read = 12.95V / Value expected = 23.24V to 28.0V
    - Value read = 13.01V / Value expected = 23.24V to 28.0V
    - This connection is titled "TAS_LDG_EXTENDED" and is connected to the following equipment:

        - Connected to KMH920:J10-3
        - Connected to KMH920:J10-125
        - Connected to KTA910:J10-3
        - Connected to EGPWC:J1-16
    - Discrete out Ground/Open – MAU(3/4)J3, Pin 5
        - Value read = 2.2V
        - Value expected = 2.0V
        - Not connected in the aircraft
    - Discrete out Ground/Open – MAU(3/4)J3, Pin 6
        - Value read = 3.0V
        - Value expected = 2.0V
        - Connected to XPDR 2 Antenna Selection in the aircraft
    - Discrete out Ground/Open – MAU(3/4)J3, Pin 7
        - Value read = 2.2V
        - Value expected = 2.0V
        - Not connected in the aircraft
    - Discrete out Ground/Open – MAU(3/4)J3, Pin 8
        - Value read = 4.0V
        - Value expected = 2.0V
        - Not connected in the aircraft
- 2 failures were associated with differential DC voltage inputs to the unit on Channel B. Those were:
    - Differential DC voltage – MAU(3/4)J3, Pins 25 and 26
        - Value read = 8.12V
        - Value expected >= 8.30V
        - These two pins are the 12VDc In 1 Hi (pin 25) and Lo (pin 26).
        - These pins are not connected in the aircraft.
    - Differential DC voltage – MAU(3/4)J3, Pins 45 and 46
        - Value read = 8.05V
        - Value expected >= 8.30V
        - These two pins are the Battery 2 Voltage read where Pin 45 is the A/C battery voltage and Pin 46 is connected to a ground in the aircraft.
- 4 failures were associated with the Flight Data Recorder (FDR) A717 transmitter out from the unit. Those were:
    - CSIO Channel A, FDR Output (Arinc 717) Voltage – MAU(3/4)J1, Pin 43 (Hi)
        - Value read = -0.0553V
        - Value expected = 0.0000V to 5.0000V
    - CSIO Channel A, FDR Output (Arinc 717) Voltage – MAU(3/4)J1, Pin 44 (Lo)
        - Value read = -0.0604V
        - Value expected = 0.0000V to 5.0000V
    - CSIO Channel B, FDR Output (Arinc 717) Voltage – MAU(3/4)J4, Pin 43 (Hi)
        - Value read = -0.0607V
        - Value expected = 0.0000V to 5.0000
    - CSIO Channel B, FDR Output (Arinc 717) Voltage – MAU(3/4)J4, Pin 44 (Lo)

- Value read = -0.0607V
- Value expected = 0.0000V to 5.0000

Analysis of Results:

Discrete Output failures:

The majority of the failures associated with the discrete outputs are not connected to anything in the aircraft. The pin 4 contains the TAS_LDG_EXTENDED (landing gear extended) signal to the various Hazard Awareness Units which are options in the PC-12NG. This would include an Enhanced Ground Proximity Warning (EGPW) computer as well as a Traffic Collision Avoidance System (TCAS). The remaining failure was on Pin 6 and is a signal to the XPDR 2 as to which antenna has been selected for use in the aircraft. The fact that all of the discrete outputs slightly failed on the low end would tend to indicate that there may be a grounding issue from the Channel B card to the front plate of the module. Further testing would be required in order to determine if the front plate grounding on the Channel B card is the source of the failures. While these results were not within specification, it can be concluded that these failures would not have been germane to the accident.

Differential DC Voltage Failures:

The failures of the differential DC voltage inputs could not be determined at the time of testing. The differential DC voltage inputs passed their gain and accuracy tests, but their input impedance was not within specification. As one of these inputs is not connected in the aircraft and the other has only to do with a slightly out of tolerance read of the aircraft's battery 2 voltage, it can be concluded that these failures would not have been germane to the accident.

FDR Transmitter Failures:

The failures of the FDR A717 outputs could not be determined at the time of testing. The FDR outputs are slightly negative at the test scenario of the failure and it is unknown how this would have affected the FDR's ability to read the data being transmitted. Similar to the discrete output failures, it is likely that the source of the FDR failures is the result of a poor ground between the channel B card and the front plate of the module. Further testing would be required in order to determine if the front plate grounding on the Channel B card is the source of the FDR failures. The channel A FDR A717 connection is not used in the aircraft. While these results were not within specification, it can be concluded that these failures would not have been germane to the accident.

Other Important Test Results to Note:

- All tests associated with the read of the engine torque signal (CSIO Channel A, MAU(3/4)J2, Pins 55 through 62) resulted in values that were within the required specification.

Fault Hazard Database (FHDB) File Decoding:

A download of the fault data (PB1) files from channels A and B was performed per the procedure given above. A decoding of the PB1 files for both channels determined that, on the day of the accident (1/6/2016), the only faults recorded were "blind resets". These are typically recorded when a unit's power is removed or when a reset occurs (IE: watchdog or heartbeat resets) which could be the result of a power interrupt or a power cycle by a user. If the faults found were the result of a power cycle or reset of the CSIO during the takeoff, this would have resulted in the loss of information from the CSIO during the power cycle and then the return of the information after the unit was back up and running within a few seconds. According to the files downloaded, both units showed "blind resets" in the same number and around the same times on 1/6/2016.

Figure 1. CSIO Module in Packaging as Received

Figure 2. CSIO Module Being Removed From Protective ESD Bubble Wrap

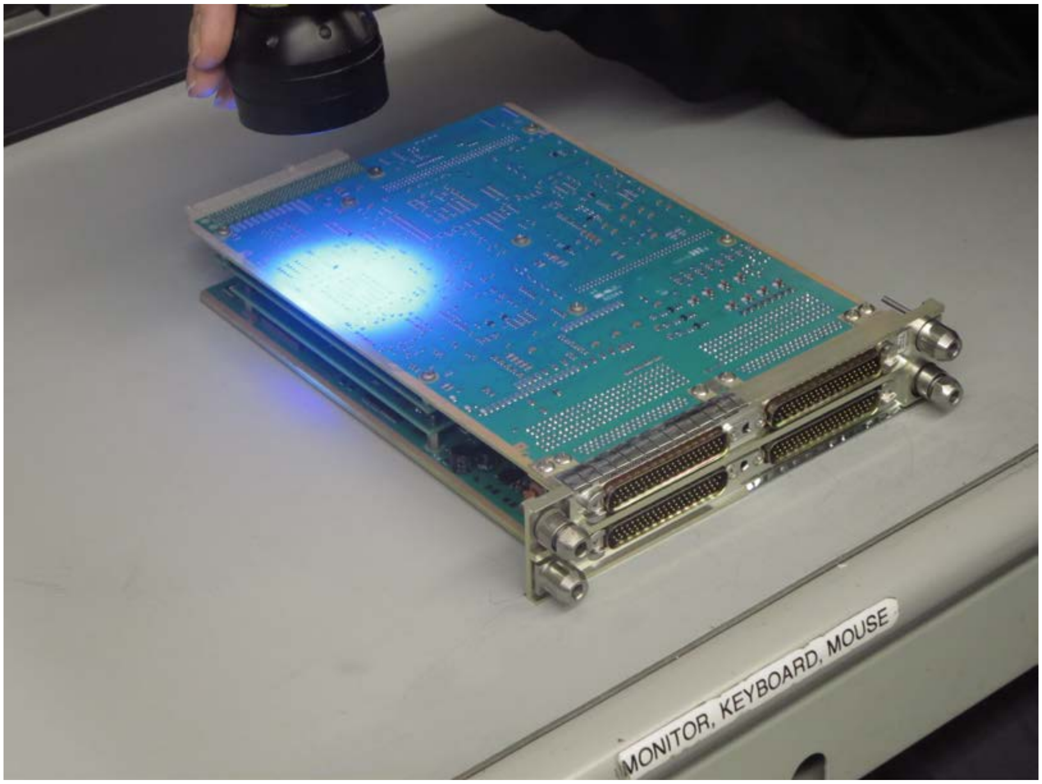

Figure 3. **CSIO Module Being Inspected With A Black Light**

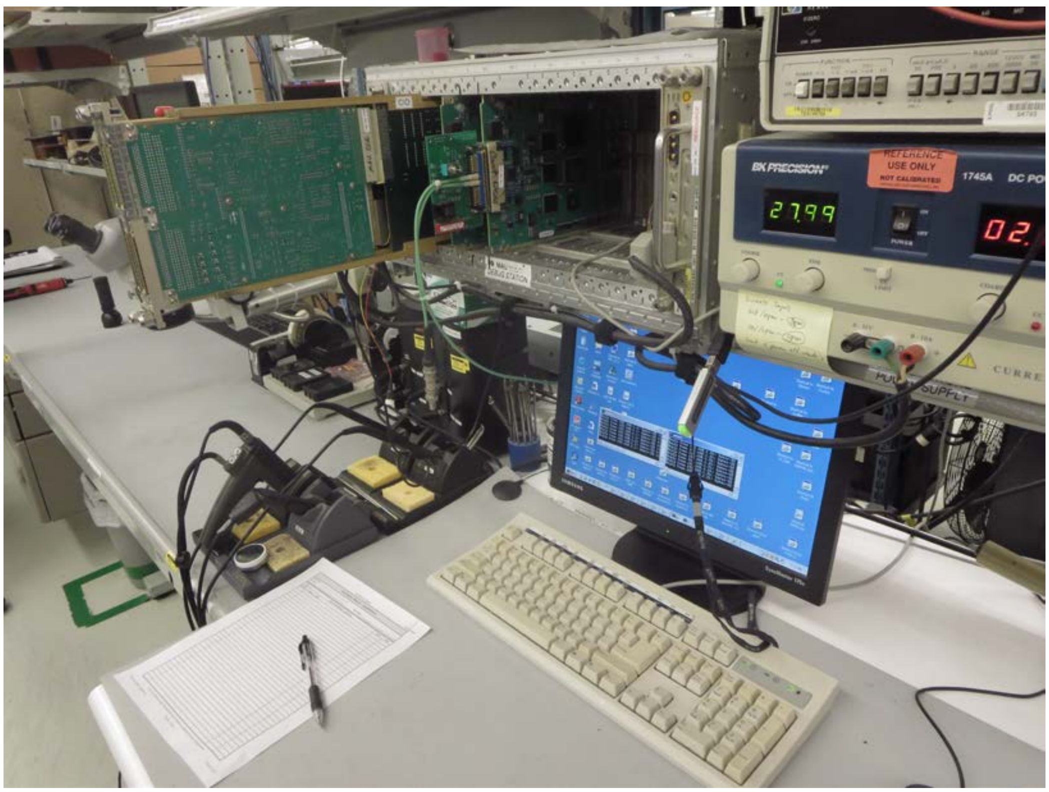

Figure 4. **CSIO Module Installed Into Test Fixture for Downloading**

Figure 5. **CSIO Placed in the JTAG Hbit Loading Fixture**

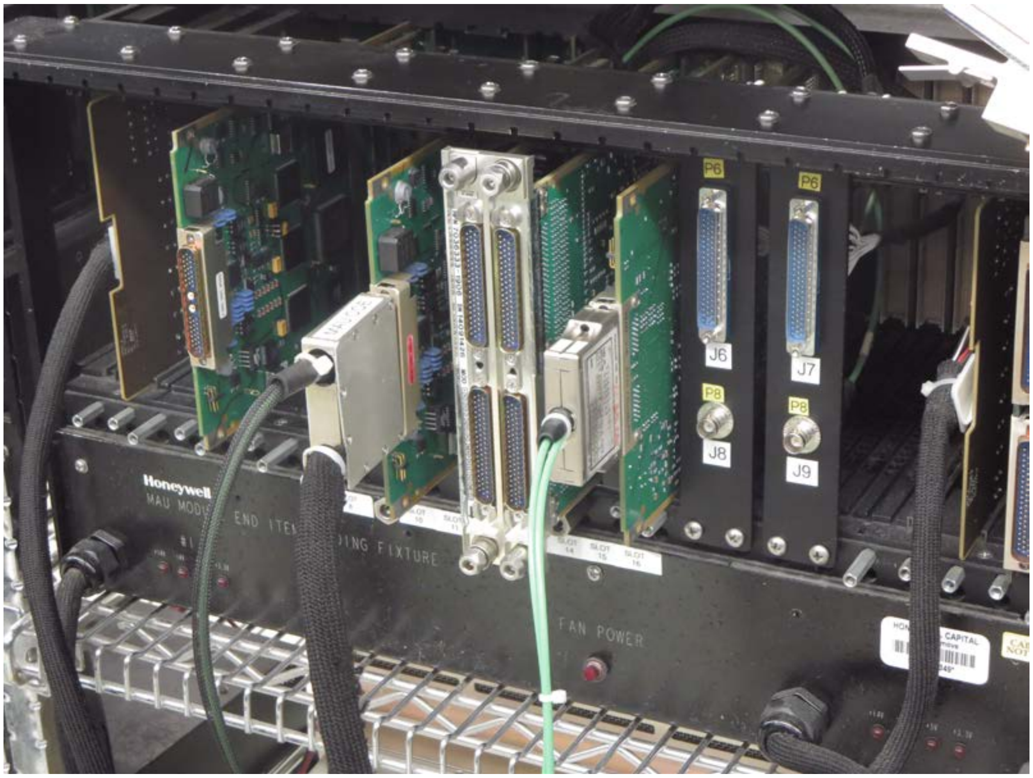

Figure 6. **CSIO Placed in the Vector Test Platform**

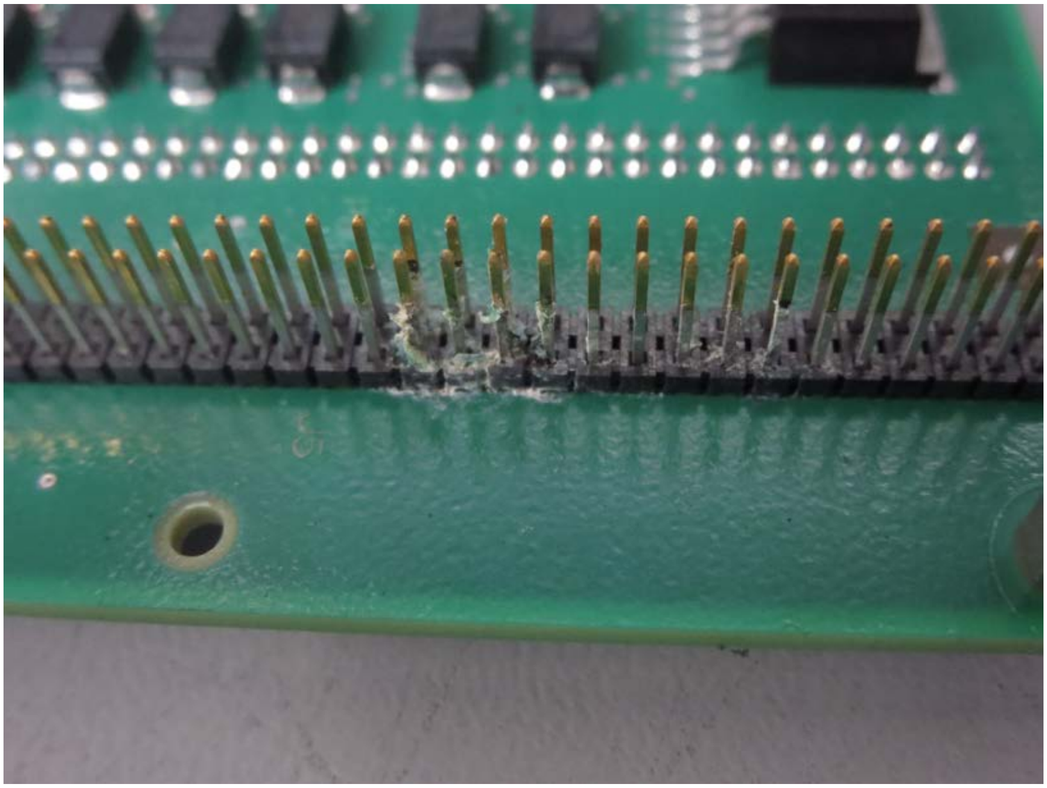

Figure 7. “Growth” Identified Within CSIO Module