

Universal Synaptics

Intermittent Fault Detector™ (IFD-256™)

Customer Removed – Boeing 777 GE90 Engine Harness

Wire Bundle Assembly 286W0751-302 / 286W0752-302

Test Summary



Prepared and Submitted by:

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Wire Bundle Assembly (286W0751-302 / 286W0752-302) S/N: 6693415

Introduction:

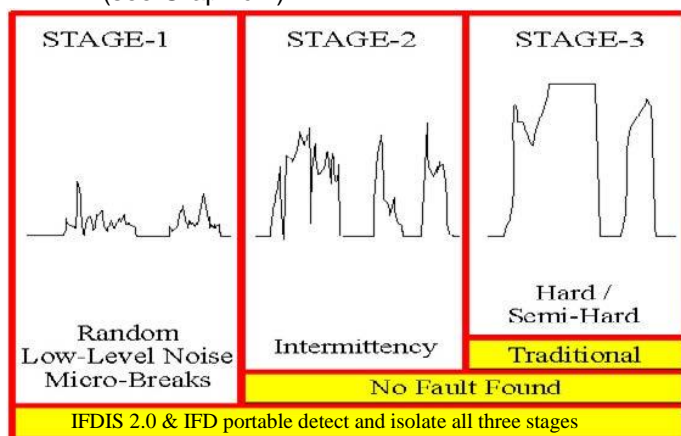
The subject harness provided by **Customer Removed** was given to the Universal Synaptics (USC) / Barfield, Inc. team on site at **location removed** - Maintenance Facility. Testing was conducted to demonstrate Intermittent Fault Detection™ (IFD™) technology and was coordinated by Barfield and **customer removed**.

Selection of the GE90 wire bundle assembly was based on No Fault Found (NFF) rates and recurring unscheduled/unplanned maintenance costs caused by the 751/752 segments of the harness – a recent aircraft issue caused by the subject harness reached nearly \$500K in maintenance costs. Harness S/N 6693415 was selected as the test case for demonstration after it was returned to **customer removed** from the authorized repair facility as Serviceable and Ready for Install (RFI) in accordance with the approved maintenance manual and industry standard testing with conventional wire test methods (troubleshooting tools – Digital Multimeter (DMM), Megger and/or Automatic Test Equipment (ATE)).

Testing was conducted to demonstrate the advanced prognostic / diagnostic capability of IFD™ technology. USC and Barfield arrived with the portable IFD™ test set and GE90 wire bundle assembly Interface Test Adapter (ITA), that was designed, developed, and manufactured by Universal Synaptics. No Test Program Set (TPS) was developed or required prior to arrival, due to the portable IFD's AutoMap™ capability.

Test Procedures:

- **AutoMap™** – discovered the Unit Under Test (UUT) true as-wired configuration
 - S/N 6693415 was used as a baseline “gold” unit to establish UUT profile (feasible because the test asset was considered “serviceable” based on a standard functional test of ohmic resistance)
- 1. **Continuity** – tests for open circuits and measures resistance against established AutoMap baseline (open circuits / high resistance tests)
- 2. **Shorts** – provides shorts indication and shorts tracing
- 3. **Intermittence** – monitors all circuits to detect and isolate *all three Stages* of intermittent faults (see Graphic 1)

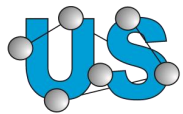


Graphic 1 – Three Stages of an Intermittent Fault

Stage 1 – random low-level nanosecond micro-breaks, likely not operationally evident yet, but on curve of degradation to become Stage 2

Stage 2 – intermittent failure evident to pilot in operation, reported to ground crew, passes ground test and labeled No Trouble Found (NTF) or No Fault Found (NFF). On curve of degradation to become Stage 3

Stage 3 – semi-hard or hard failures, Automatic Test Equipment (ATE) and troubleshooting tools such as DMMs designed to detect hard faults (open circuits or shorted circuits)



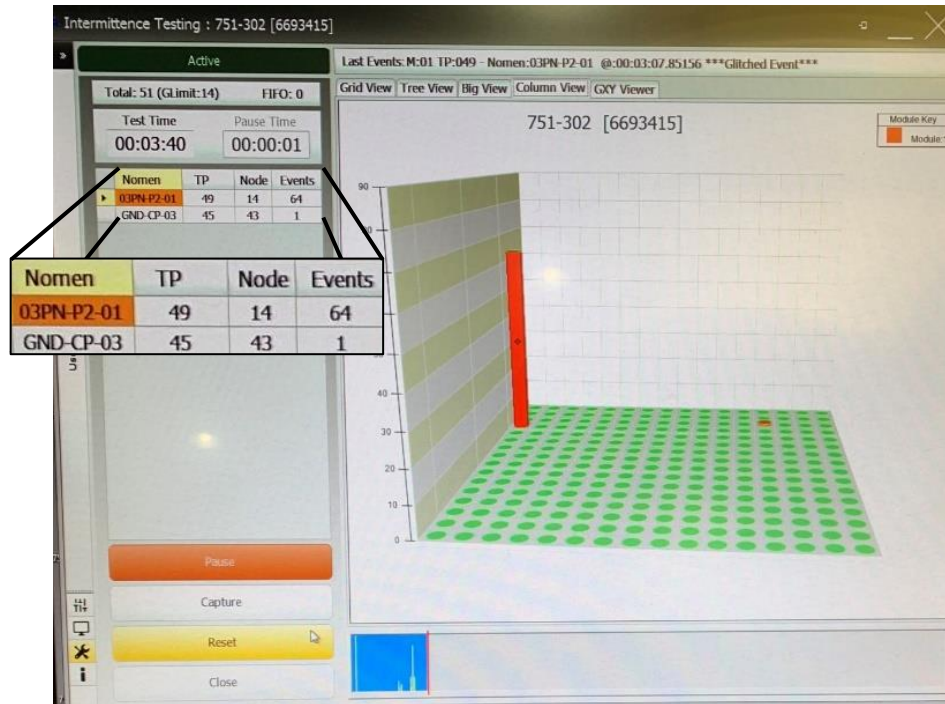
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Results:

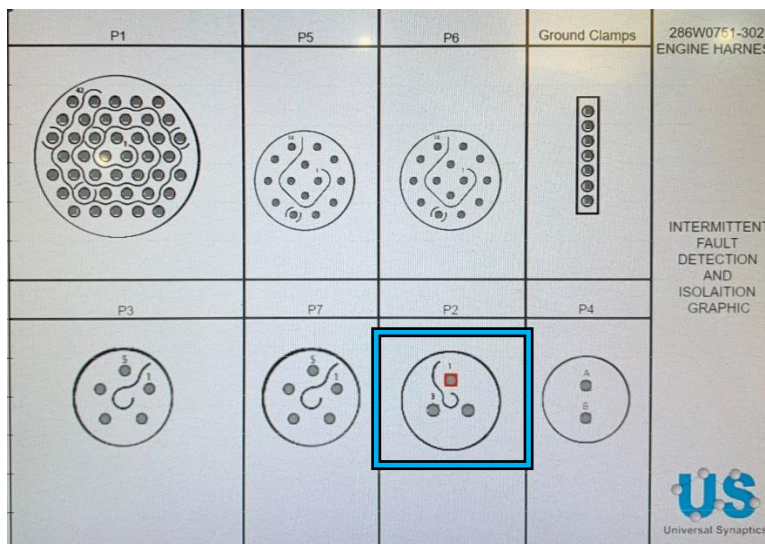
S/N 6693415 – 286W0751-302

Test Date: 9 March 2020

1. IFD-256 Continuity testing conducted – no open circuits present in the UUT
2. IFD-256 Shorts testing conducted – no shorted circuits present in the UUT
3. IFD-256 Intermittence testing conducted – multiple intermittent events (64 discrete intermittent events) detected on 03PN-P2-01, Test Point (TP) 49, Node 14 with light, manual manipulation of the harness (see Graphic 2); P2 connector with intermittent events can be viewed in Graphic 3 and 4. One intermittent event detected on GND-CP-03, TP 45, Node 43.



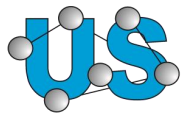
Graphic 2 – Intermittent Graphic - S/N 6693415 – 286W0751-302



Graphic 3 – Fault Isolation Graphic – P2 Connector with intermittent fault



Graphic 4 – Actual P2 Connector



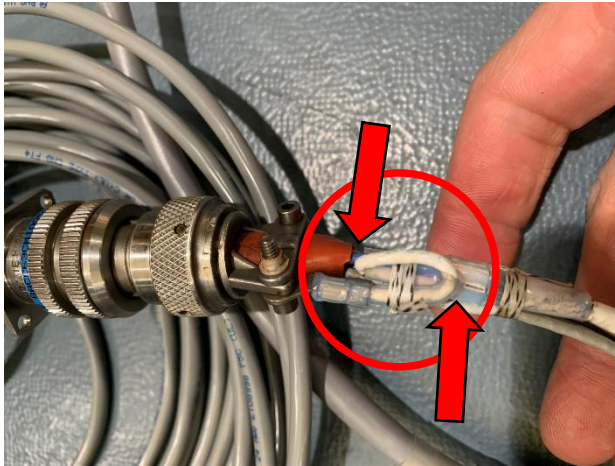
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Recommendation:

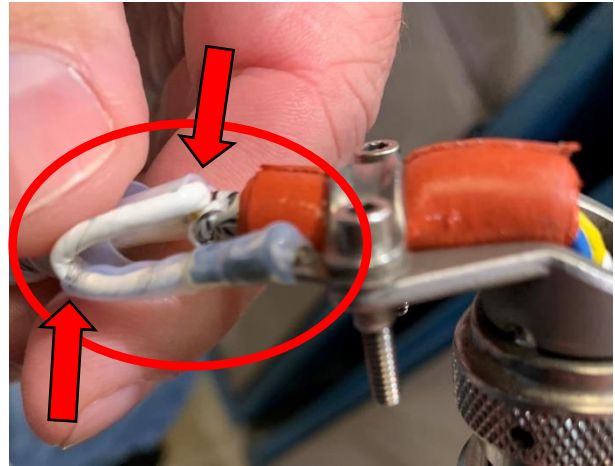
- Recommendations Removed

Observations:

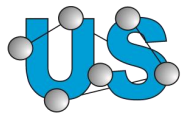
- Conventional ATE / troubleshooting tools and techniques are severely limited and did not find these intermittent faults (see Graphic 1 – Three Stages of an Intermittent Fault)
- The portable IFD test deemed this GE90 wire harness to be unserviceable that requires a repair action before release to the aircraft – CMM procedures do not include troubleshooting for or repairing intermittent faults, therefore the wire harness was returned to service with a known intermittent fault
- When this wire harness fails in operation and returns to the repair facility, it will likely test No Fault Found (NFF) with current FIM / CMM testing procedures



Graphic 5 – Ground Wire to P2 Connector



Graphic 6 – Ground Wire to P2 Connector



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Results:

S/N 6693415 – 286W0752-302

Test Date: 9 March 2020

1. IFD-256 Continuity testing conducted – no open circuits present in the UUT
2. IFD-256 Shorts testing conducted – no shorted circuits present in the UUT
3. IFD-256 Intermittence testing conducted – no intermittent faults present in the UUT with light, manual manipulation applied while IFD monitoring all circuits of the UUT simultaneously and continuously

Summary:

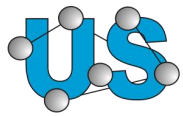
Universal Synaptics' patented Intermittent Fault Detection technology has proven to increase aircraft component reliability. As proven by this demonstration, the IFD-256, once implemented, will increase the reliability of the aircraft by ensuring that open circuits, shorted circuits and intermittent circuits are not present in the wire bundle assemblies / engine harnesses installed on Boeing 777 GE90 engines flown and maintained by **customer removed**.

The ability to detect and isolate intermittent faults in wiring harnesses and components, thus preventing Operational Difficulty Index (ODI) events and customer dissatisfaction, will save **customer removed** on unnecessary expenses associated with NFF. The Air Transport Association (ATA) estimates NFF costs the commercial aviation industry \$250,000 per year per aircraft. Testing wiring harnesses and components in accordance with the FIM or CMM designates them "serviceable" from a requirement perspective but does not solve the issues lurking beneath the surface that conventional test equipment and troubleshooting methodologies cannot detect and isolate.

Additional Information:

The USC / Barfield testing team was invited back to brief and demonstrate IFD technology for additional technicians and engineers on 10 March 2020. Harness 286W0751-302 was the only portion of the wire assembly tested by the portable IFD.

The same test procedures were followed with the same intermittent results manifesting on Connector 03PN-P2-01, Test Point (TP) 49, Node 14. The ability to conclusively replicate the same intermittent faults the next day indicates that the test subject wiring harness on the GE90 engine will most likely fail in operation.



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Additional Test Photos:



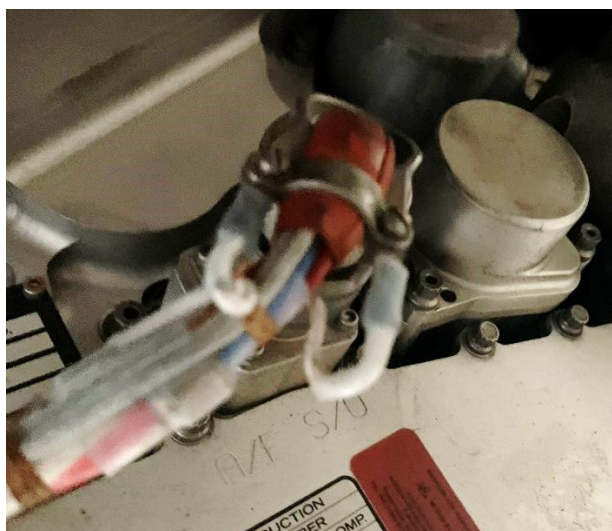
Graphic 7 – USC CXO and Technical Director in front of GE90 Engine installed on Boeing 777



Graphic 8 – Wire Bundle Assembly installed on GE90 Engine on Aircraft – in situ testing is preferable to allow UUT to function in installed environment to simulate real world environment



Graphic 9 – Wire Assembly installed on GE90 Engine – excessive wire bend prone to degradation and intermittence



Graphic 10 – Wire Assembly installed on GE90 Engine – possible excess wiring causes excessive bends prone to intermittent behavior



Graphic 11 – USC Technical Director connecting Wire Bundle Assembly to IFD interface test adapter (ITA)