

Failure Analysis – Missing Signals

Introduction:

In the ever-evolving landscape of technological advancements, ensuring the reliability and integrity of products is paramount. In *mission-critical systems* where *reliability is non-negotiable*, root cause failure analysis efforts are crucial in understanding the path forward to reliable performance for our customer's components, systems, and products. AAA Test Lab recognizes the critical role that failure analysis plays in uncovering the root causes of component malfunctions. Our failure analysis efforts enable our customers to refine their processes, enhance product performance, and bolster user confidence.

AAA Test Lab is equipped to tackle open-ended failure analysis efforts using its arsenal of advanced testing equipment. Among these tools are X-Ray Fluorescence (XRF), High-magnification Visual Inspection, Scanning Electron Microscopy (SEM), and Energy Dispersive Spectroscopy (EDS). Each of these tools offers unique insights into the structural, elemental, and morphological characteristics of materials under investigation.

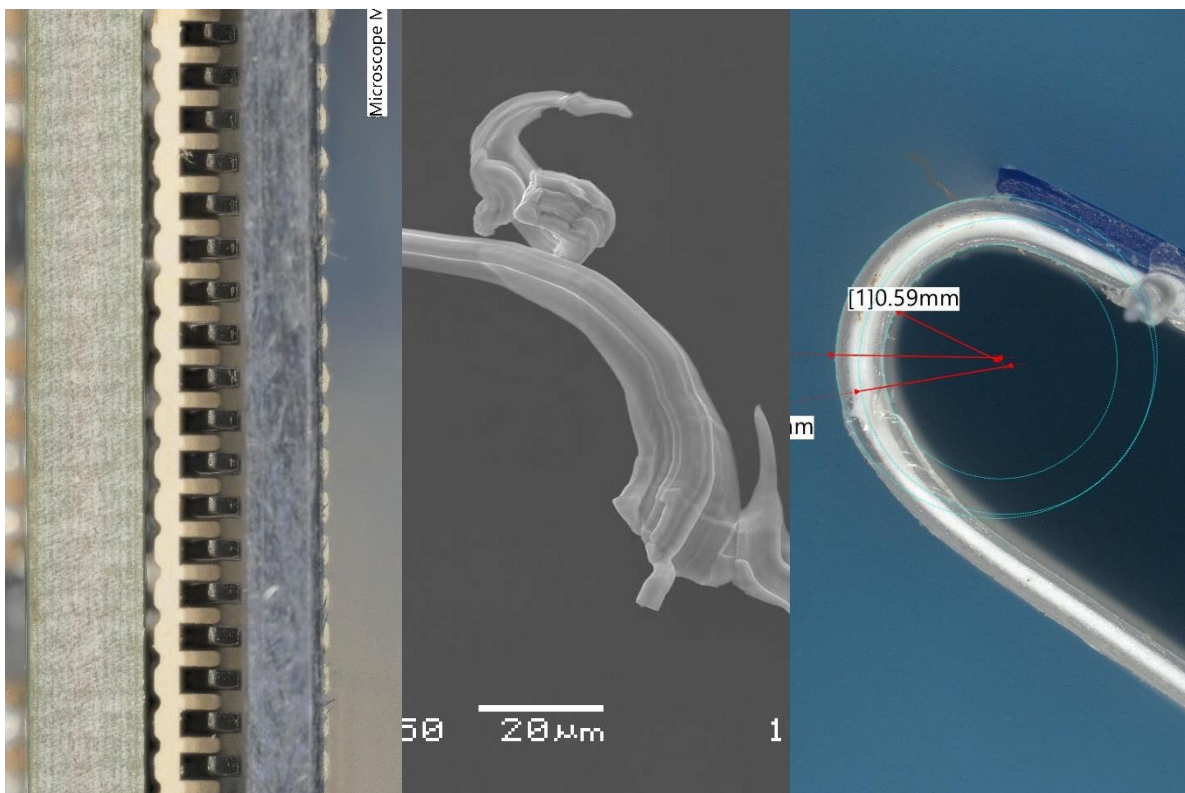


Figure 1: Sample of Photos Obtained during FA Effort

This white paper aims to illuminate AAA's rigorous approach to executing failure analysis efforts utilizing its test capabilities and engineering expertise. By delving into the capabilities of XRF, Visual Inspection, X-Ray, SEM, and EDS, it will be demonstrated how AAA Test Lab empowers the aerospace, defense, medical, and automotive industries to identify, mitigate, and prevent failures. These efforts enable innovation and excellence in product development and manufacturing processes for our customers.

Problem Statement:

AAA Test Lab was approached by a customer with a problem: their communication system was experiencing intermittent connectivity issues for no apparent reason. Signals were dropping on certain channels, and the performance of the system was uncharacteristic for no observable reason.

In failure analysis efforts, it is important to have a comprehensive understanding of the environment and situation that the failure occurred in, including factors like ambient environment, physical stability/vibration, and most importantly the user/lack thereof. The system in question consisted of an RF communication device electrically connected to a control board by a cable. The environment where the system was failing was in the field, with potential influences of elevated temperature and humidity. Working with limited information due to the sensitivity of the system, temperature and humidity were identified as potential stressors or failure modes.

From the information available, AAA's engineering team developed a plan of attack: Visually inspect the device, especially any electrical contact points up to 200x magnification. Examine and check for chemical and mechanical signs of oxidation or corrosion. Check metal surface finish thicknesses using XRF and compare to industry/multiplier standards for acceptability. Take high-magnification x-ray images at potential failure spots across the system, including solder joints and connector junctions. Utilize the SEM to check on connector pins, examining the surface for any irregularities. If necessary, simulate system performance through electrical testing and observe system behavior.

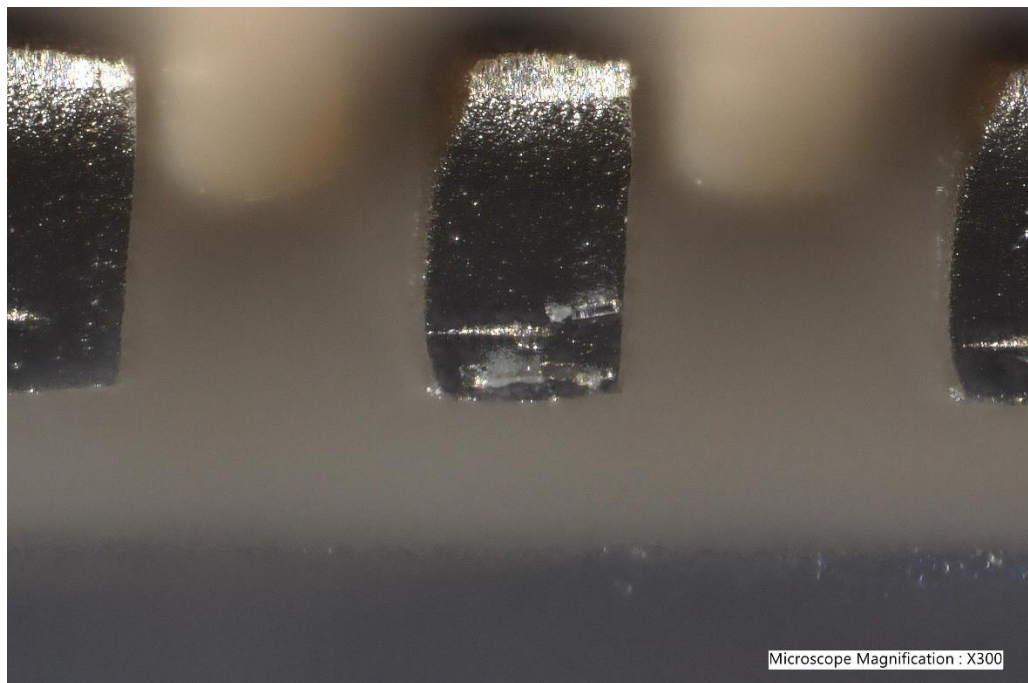


Figure 2: Visual Inspection of Connector Pins

The examination began with a detailed external visual inspection, using AAA Test Lab's high-magnification Keyence microscope. This quick step allows the team to quickly identify any glaring issues and gather clues towards where the investigation should follow next. Insertion marks were observed on the pins, leading to more detailed examination. Small regions on the pins had slightly recessed surface morphology where mechanical force of the connector pin contacting the control board had slightly removed some of the metallic surface (Figure 2). This introduced a potential source of FOD (foreign object debris) into the

system. Visual inspection also covered the possibility that the bend radius of the ribbon cables used in the connection system were being bent beyond the specified bend radius. These measurements were taken using the Keyence microscope and it was determined that the bend radius was within the manufacturer's specifications as per the datasheet.

XRF measurements were taken on the surface of the pins of the connectors, especially at locations where insertion marks were visible. Measurements were in specification when referenced against the connector's manufacturer datasheet, although tin plating thickness was on the lower end of the specified tolerance. No major failure modes were identified using XRF.

X-ray imaging was conducted next to examine the internal metal structures of the mounted connector, the cable itself, and the CCA (circuit card assembly) that supported this connection. After a thorough imaging and analysis effort of these parts of the system, no major concerning findings were observed.

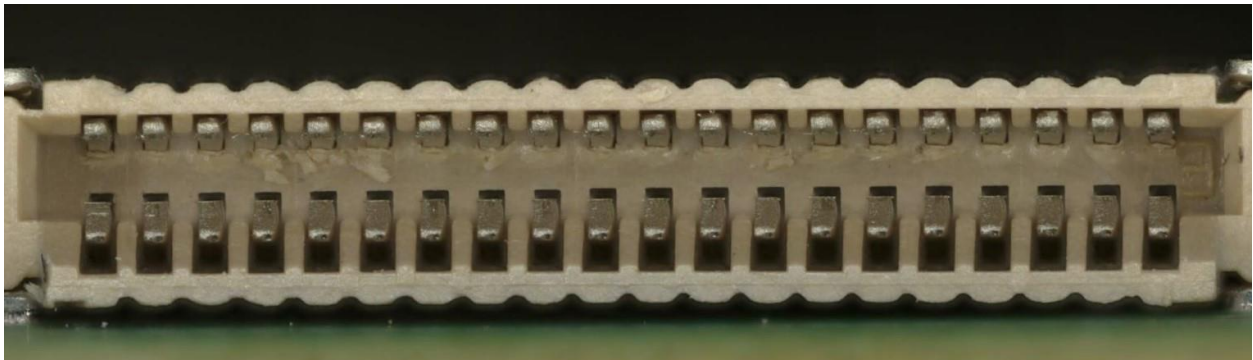


Figure 3: Connector View

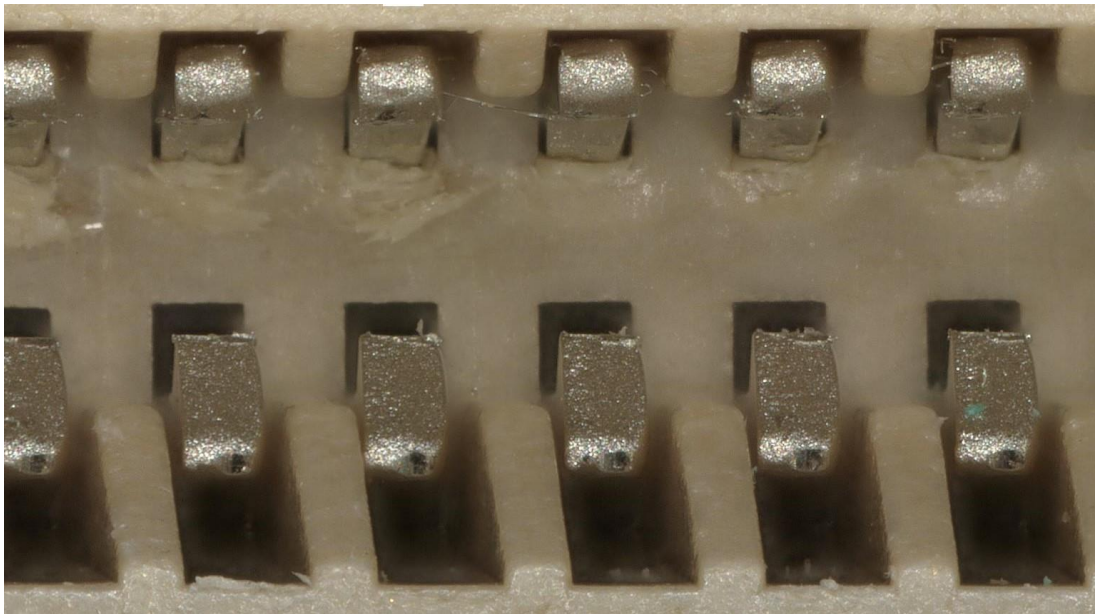


Figure 4: Connector Hi-Mag View

Destructive analysis was allowed under this effort, so a closer look at the connectors (Figure 3) with a slow, deliberate deconstruction process was up next to circle back and look for other signs of the true failure mode. This effort was fruitful, revealing the final destination for the material that was missing from the surface of connector pins. Small metallic strands were observed between the pins of the connector, potentially originating from the tin plating on the cable itself. High magnification imaging was conducted of these strands, and it was observed that the physical attachment of the strands from pin to pin could be causing intermittent shorts, interference, or uncharacteristic system performance in general (Figure 4).

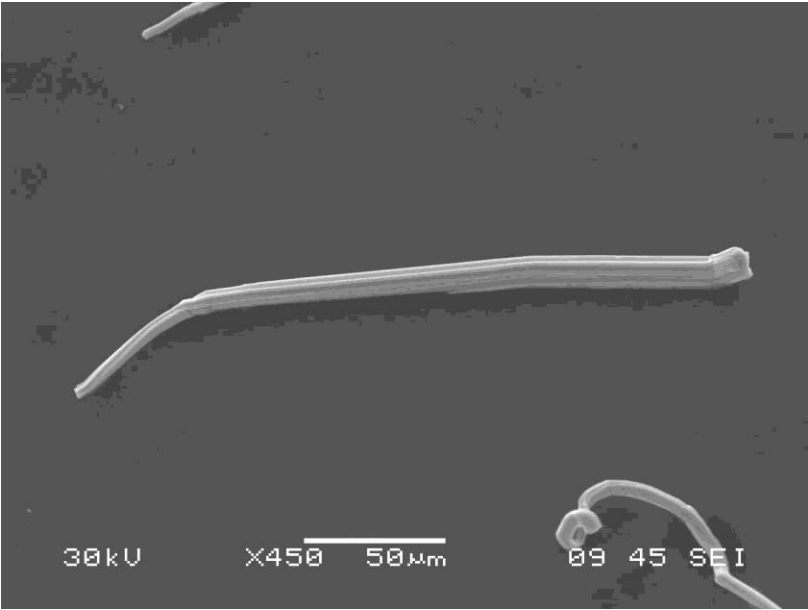


Figure 5: SEM view 01

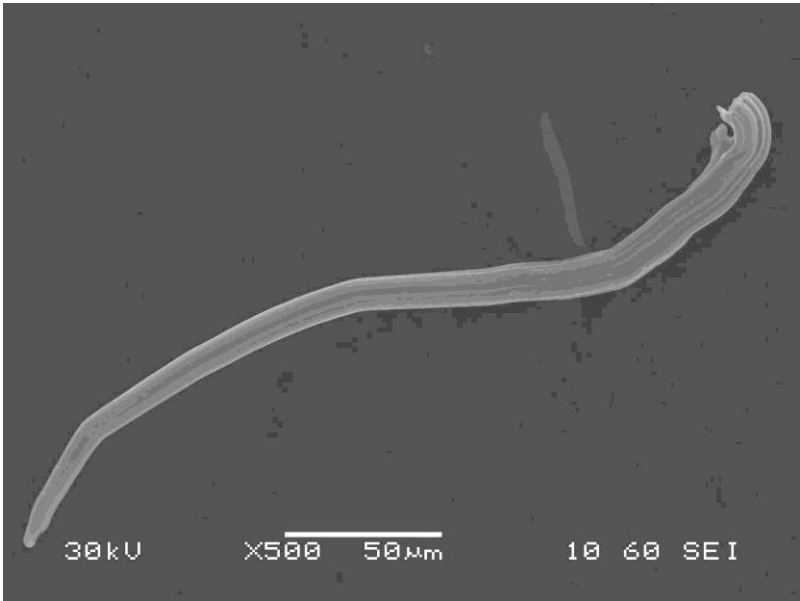


Figure 6: SEM View 02

To confirm this observation as a clear demonstration of the root cause of failure, a closer look was taken at the strands. AAA's skilled inspector team carefully removed the strands between the pins, despite the clearance and average feature scale in this area being on the order of thousandths of an inch. The strands were isolated and adhered to a conductive surface to allow for examination in the SEM.

SEM analysis began with a general observation of the samples, taking a scientific look at the size, shape, and structure of the strands. At the nanoscale, the engineering team drew conclusions of the structure's origin based on the shape, form, and size of the observable features (Figures 5&6). Mechanical grooves were observable, and while there was a concern that these metal shavings were visually similar to tin whiskers, the size of the samples observed were not in the known size range of tin whiskers. EDS Analysis also allowed the team to conclude that the shavings were metallic in origin and could be causing intermittent shorts and signal losses across the pins of the connector.

Armed with the observations and conclusions provided by AAA Test Lab, the customer was able to move forward with a process correction to enable their product to be successful and fulfill its required operation.