Photos courtesy of Rockwell Collins

# Untangling ISSUES WITH AGING AIRCRAFT WIRING

STORY BY DALE SMITH

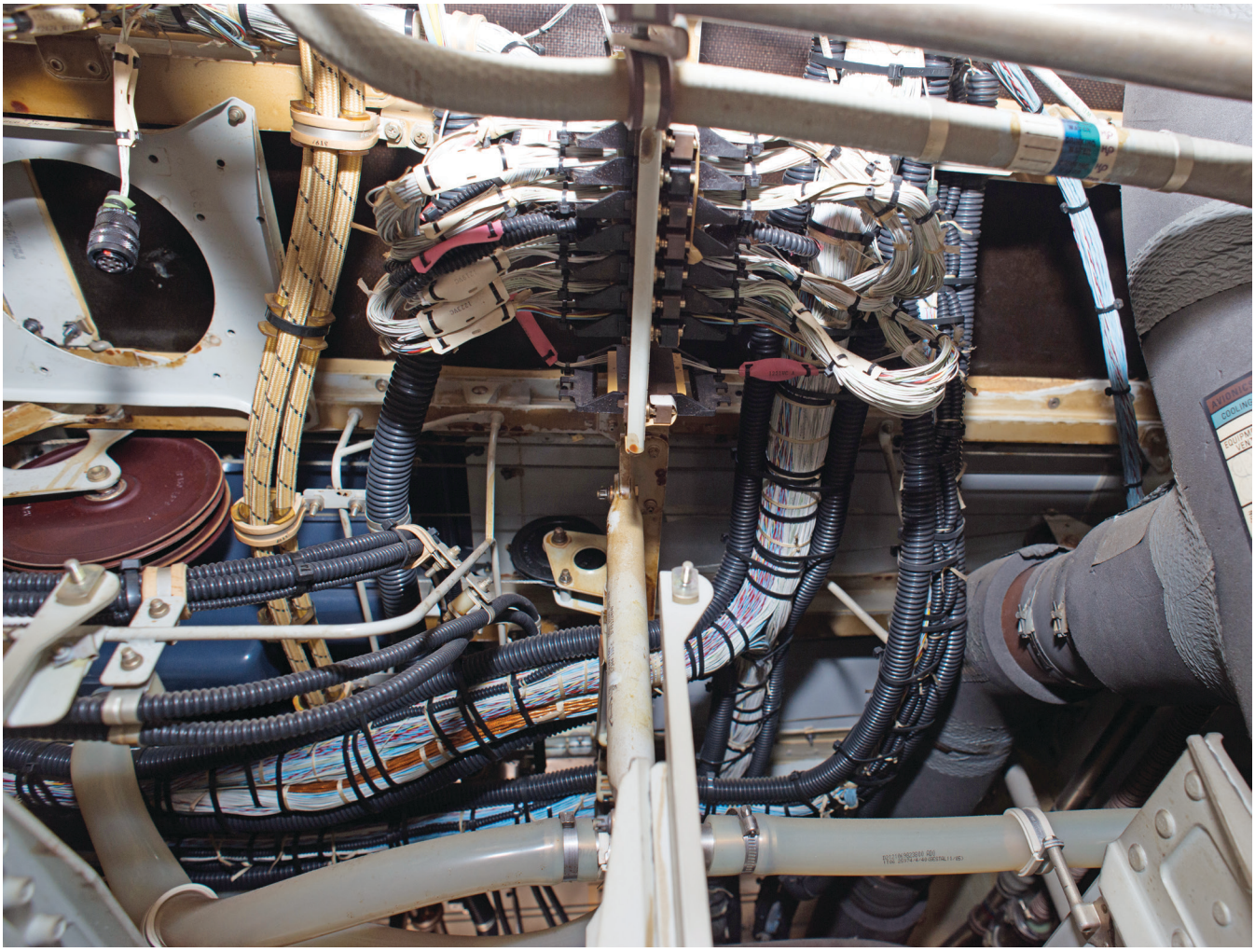
During a recent informal and unscientific survey of avionics technicians, *Avionics News* posed the following question: What task do you really hate doing?

The technicians surveyed ranked completing their annual personal performance evaluation at the top of the list. Coming in a close second was troubleshooting electrical/wiring issues.

If that surprises you in any way, it's clear you've never tried to trace down any sort of wiring issue. While troubleshooting any electrical problem is challenging in the best situations, it can be downright maddening when the electrical problem is intermittent – which, unfortunately, seems to be the case in the majority of situations.

"When servicing an aircraft for an electrical issue, the fastest path often is to replace the unit not operating properly versus troubleshooting the wiring," explained Jessica Busse, technical support manager for Textron Aviation. "But just changing out LRUs is an expensive route and doesn't always fix the problem."

According to Stephen Scover, vice president and general manager of lighting and integrated systems for Rockwell Collins, "What we frequently find with shipside problems with intermittent electrical performance is that when you change that component with a new one, you'll end up with a bad actor. While that may seem to solve the problem, the



*Having a thorough understanding of an aircraft's wiring and the various issues associated with temperature, wear and corrosion can greatly reduce the challenge of troubleshooting an electrical issue on an aging aircraft.*

fact is, it doesn't. In many cases, when the technician returns the failed component to us for analysis, it tests out perfectly. That's when you conclude it's not the unit but is actually a problem within the wiring. Sometimes, the new component works, and then in a while it quits. Because the issue comes and goes, it's extremely frustrating for everyone."

As you may well guess, the problem with intermittent, bad actors is their occurrence becomes more frequent as the aircraft's systems, wiring and connectors get older.

## Aircraft wiring: There's a lot of it.

For the simple fact that it's all hidden, it's easy to lose track of exactly how much wiring there is in a post-1960s airplane. How much wiring? According to Textron Aviation, for example, the typical Citation X has 800 pounds of wiring running throughout its airframe.

But 800 pounds of wiring in a super-mid-size business jet isn't a lot. That's true. But when it comes to wiring, it's not the weight, it's literally the mileage. Pick up a 1-foot piece of 12-gauge wire. How much does it weigh? Not much. Now imagine how many of these 1-foot pieces you would have to string together to make 800 pounds. That's a lot of wire.

And that's in a Citation X. If you ever find yourself with a 787 to troubleshoot, you're looking at nearly 100 kilometers of wiring, 3,500 connectors and nearly 40,000 cable segments. While that's plenty to get the typical avionics technician to look for alternate employment, the good news is Textron Aviation, Boeing, Airbus and every other airframer has gone to great lengths to ensure that most technicians will work their entire career and not have to troubleshoot a single wiring issue deep inside the airframe.

"When a modern aircraft wire harness is properly designed, assembled and installed, I would expect the lifetime of those components to be as long, if not longer, than the airframe itself," Scover said. "It's a robust system overall. But you start to see failures in areas where there is repeated mating and unmating of connectors, or where wiring is coming in contact with the airframe.

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"Most issues with connectors are due to repeated component replacements or during a cockpit or cabin upgrade. When that occurs, it's normally your only chance to get up inside the airframe to inspect wiring harnesses that haven't been exposed since the day the airplane was assembled."

Scover noted that when you're looking for signs of impending wiring problems, some of the obvious signs are insulation beginning to crack and peel.

"You want to look at the entry points where the wire goes into the socket or connector plug," he said. "You need to visually inspect those entry points, and if you see anything unusual, move the wiring back and forth to see if it's coming loose. If there's any play in the mechanical connection, it needs to be fixed immediately."

"Another area that needs inspection and attention are the various ground points you find in a wiring harness," stated Michael Vercio, Textron Aviation's vice president for product support. "Over time, corrosion, dirt and moisture will start to build up around the ground points and connectors. Also, the airframe expands and contracts with temperature changes, so the wiring itself can stretch and will allow moisture to get in around the connectors.

"It's a slow process, but over the years it can take its toll. Also, the rubber grommets where the wiring passes though the airframe can deteriorate. As the airframe vibrates, the wiring can start to chafe against the metal. That can lead to a lot of shorts or intermittent-type issues."

Vercio said that whenever possible, technicians need to visually inspect the pliability of these grommets to ensure they are providing the necessary protection for the wiring. Since they are primarily made of a rubber compound, temperature swings and moisture can work to degrade their condition. But that's not the only area that warrants periodic visual inspections.

"Over time, technicians may also see strain relief on a connector that does not provide as much relief as it once did," Busse added. "In turn, this relief degradation pulls the wires at the crimp or solder joint and leads to intermittent issues in that signal or component."

She also said technicians should closely inspect the wire anchors to make sure zip ties are properly installed – too loose and the ties will allow the wiring to rub against the ties or airframe, damaging the insulation over time. If the ties are too tight, they can prevent the wires from any movement, which will also cause damage to the insulation jacket and possibly the pin connections.

"As the aircraft ages, it will frequently expose improper installation techniques including overcrimping, improper strain relief routing, incorrect drain loop installation, and incorrect zip tie pressures," Busse said. "The whole wiring system needs to be considered when looking at aging – from where the wire routes, to where it is located, and most importantly, how it terminates in the aircraft. Corrosion is a big problem at the termination and grounding points."

"With regards to corrosion prevention and control, as a manufacturer, we are taking steps to minimize these issues going forward," Vercio said. "One of those has been the routine application of corrosion inhibiting compounds to the connectors and plugs during assembly, especially in areas of the airframe outside the pressure vessel. CICs improve bonding and cut down on the instances of corrosion- and vibration-related issues."

> WHILE TROUBLESHOOTING ANY ELECTRICAL PROBLEM IS CHALLENGING IN THE BEST SITUATIONS, IT CAN BE DOWNRIGHT MADDENING WHEN THE ELECTRICAL PROBLEM IS INTERMITTENT – **WHICH, UNFORTUNATELY, SEEMS TO BE THE CASE IN THE MAJORITY OF SITUATIONS.**

## When you're just looking for trouble

Busse offered some insightful tips to help when it comes time to troubleshoot a suspected wiring issue.

"The first is to talk to the flight crew (or aircraft owner) and learn what issues they are experiencing and when," she said. "Parameters include what configuration the aircraft was in as to altitude, temperature, time and even how other components were operating at the time. Technicians need to also find out if there has been any recent maintenance on any aircraft systems. They can combine that information to determine what tests you want to run and what wiring you need to evaluate.

"Next, analyze the wiring diagram of the system you

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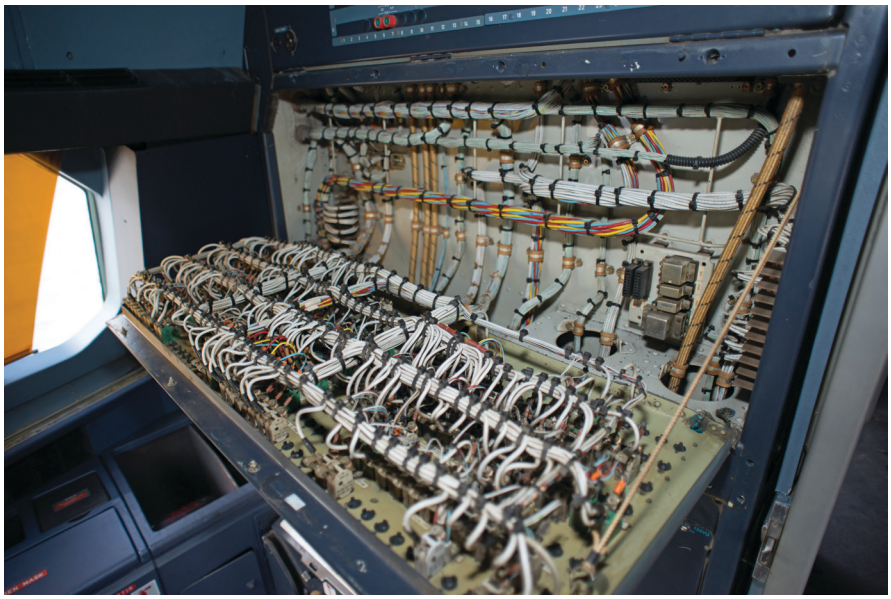

are working on. Understand all the components, their exact location and the wire routing between those various connections. If there is an issue with a component and the wiring passes through a wheel well or engine bay, then do not overlook that area as a source for the issue. Physically accessing that area and then pulling and shaking the wiring harness will often get you close to your problem.

"Another tip is to take resistance readings on the wiring in relation to ground. These readings are usually defined in the aircraft's maintenance manual. Using a mega ohmmeter is an effective tool to check for insulation breakdown, but the technician needs to give careful consideration to all the components in the system. It may be necessary to isolate all from the end components to prevent erroneous readings that occur when the LRU or electrical components are still connected.

"Lastly, heating the suspect wiring with a heat gun and/or cooling it with freeze spray are both great tools in some applications. Often, systems or components will work on the ground but will fail when exposed to adverse conditions like excessive heat or cold. Subjecting the wiring to those conditions can simulate the environment and cause the failure for you to see."

## Wire 101

Another thing that technicians on the prowl for problems should consider is the type of wiring that was originally used in the installation. Some types are more susceptible to long-term temperature, wear and corrosion issues than others.

"There is a lot of inclination with technicians that 'a wire is a wire,' and that's not the case with aircraft," Scover said. "If you look at the technology behind a piece of modern wire, there is the core wire itself, the gauge, the tolerance on that gauge and the jacket material, which itself has to be approved for flammability and toxicity."

Scover said that when you get right down to it, there is a specific type of wire that can be used on aircraft, and some airframe OEMs actually call out a particular type as their approved replacement wire.

"You can't go to your local store and pick up some X, Y and Z wiring to build a specific harness," he said. "Taking it a step further to the terminating end, while an automotive type connector may be robust, waterproof and meet environmental conditions, you cannot use them on an aircraft. Like wire, there are specific connectors that are approved for airplanes and helicopters.

"So just using any 16-gauge wiring or connector won't work. There is a lot of engineering that goes into designing and manufacturing an aircraft's wiring harness. Don't make the mistake of diminishing the technical importance of selecting the proper components for each installation and repair."

When it comes to making the repair-versus-replace decision regarding wiring and harnesses, Scover said if you are starting to see fraying of a connector or wire chaffing around a mechanical structure, these are signs that the harness has reached its useful life and the best practice is to replace the entire harness.

"My personal opinion is that some types of repairs, while they may make economic sense at the time, aren't good decisions about the long-term performance of the harness," he said. "It's true for harnesses that are easy to get to and especially true for those that are difficult to access. It's foolish not to change any damaged harness, especially once you have all the interior removed and have easy access to the component.

"Even if it's only one bad wire, it's the precursor of more problems to come. If there's something there, the best way to deal with it is to be proactive. Proactivity is the most cost-effective form of maintenance no matter the problem. Maintenance is certainly not cheap. But doing it again is twice as expensive. Going back always costs more."

"No matter what you do, use proper techniques from the aircraft's manufacturer to make any repair," Busse added. "Always use approved components and corrosion-prevention materials." ❑