FEATURE ARTICLE

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Testing 1, 2

Part 1: Enduring Challenges

According to George, product testing should be more like a torture chamber than a sound check. In this series, he explains how the value of extreme test routines is more important than the cost of those routines. Before this set is over, you will understand why not running electrostatic discharge, electromagnetic immunity, or power and operational shock tests can leave you singing the blues over smoldering electronics.

Let's face it, whining about unfair offshore competition paying employees 25¢ per hour or politicians demanding protection from imports will not put us back in the electronics-industry driver's seat. The truth is, the impact of the labor rate on the overall cost of an electronic product is small. Quality makes the difference. Quality engineering, design, and manufacturing are what will give us the edge. If the product we build is returned for any reason, we lose.

Good quality starts with engineering, and in this series of articles, I look at engineering a product to work with the abuse and challenges of the real world. In aerospace, because we're always under pressure to prove to independent agencies the quality of design and manufacturing, we've always worried about safety and reliability. I've never considered it an expensive burden foisted on us by government bureaucrats, because North American travelers don't want the carnage on the runways that 99.99% acceptable quality might bring.

Obviously, not every product needs to be subjected to the formal qualification testing of a safety-critical airborne flight controller. However, every engineer should understand the environment the product may be subjected to and devise appropriate test programs to ensure that the beloved widget will survive. It will be money well spent.

In this series of articles, I discuss the environmental tortures our designs have to endure and then I'll look at practical solutions.

A BIT OF BACKGROUND

In the good old days, flight controls consisted mainly of cables and pulleys with some hydraulic valves and actuators. Because there wasn't much sophistication and very little to go wrong, reliability wasn't a major worry. However, today's sophisticated flight controls comprise electronic servo systems (collectively referred to as "fly-by-wire") with many parts that might fail, as well as software, and—unlike in the PC industry—cannot solve its problems with the three-finger salute. This same trend towards a higher level of technology exists in all areas of our daily lives. Part of the price we pay for sophistication and system intelligence is in more design effort to achieve reliability.

No matter what an electronic device is expected to do, its functional design is only a small part of the entire design process. Even when we can demonstrate it working flawlessly on the bench, we're still asked how we know that our circuits will continue to work in the real world. The question for us becomes: what do we have to do to ensure that our device maintains its precision and reliability, despite temperature variations, lightning storms, or when all hell breaks loose (see Photo 1)?

Before we start testing our equipment in a wide range of environments, it's a good idea to define a standard or a composite of conditions the product is likely to encounter. It's not surprising that the

Photo 1— To protect an electronic controller from the effects of harsh environment, its package looks like a brick, yet it is deceptively light because it is usually machined out of a solid piece of aluminum. You can drive over this baby with a truck or dunk it in the water and it won't lose a beat.

military is on the forefront of defining standardized operating conditions. In North America, MIL standards set the pace. Although we love to hate them, they are well thought out and, for that reason, have served as a template around the world.

For many years, the MIL standard was the only standard of the aerospace industry, but because they had been designed to apply to a great variety of military hardware, from submarines to missiles, commercial standards were developed by the RTCA specifically for aeronautical applications. There are many similarities between MIL and RTCA standards. Today, RTCA standards are accepted around the world and, in many instances, have been accepted by the military in place of their own, more traditional MIL-STD.

HARD-WON EXPERIENCE

I'll use the aeronautical environment to demonstrate my points, but the conclusions are applicable generally. The idea behind environmental standards is simple: by defining a set of standard conditions that encompass the majority of applications with a good safety margin, we have a known operational baseline for all equipment. The equipment will be exposed to these conditions during qualification testing, and the test results give us a benchmark to evaluate in-field performance.

The operating requirements and their verification tests can be roughly divided into two categories: environmental and electrical. In the military world, three standards are used:

- MIL-STD-810 governs environ mental requirements
- MIL-STD-461 addresses EMC (electromagnetic compatibility)
- MIL-STD-704 deals with the operating power

RTCA unified these requirements into one standard, DO-160, now in Revision D.

When specifying a piece of equipment for its ultimate application, we define the environmental conditions in which our equipment will have to work (see Photo 2). Let me give you a word of caution. Designers often assume that, once they've met all the test requirements that the customer (or boss) has specified, they are off the hook and assume no more responsibility for system performance. Nothing is further from the truth. Passing all the qualification tests demonstrates that you're on the right track, but it by no means guarantees the job is done. No amount of laboratory testing can exhaust all the possible conditions that nature has in store. Let me illustrate my point.

WHAT'S THE WORST THAT CAN HAPPEN?

Consider this example. A flight-control surface began to oscillate after several months of aircraft service, and exhaustive testing of the system on the ground revealed no problem. Eventually, the culprit was found in the RVDT used for position feedback. The seal around the shaft was not perfect, allowing a small amount of moist air to be sucked in every time the aircraft descended and the air pressure changed. Condensation formed when the warm, moist air entered the still-cold RVDT.

Eventually, enough condensation was trapped inside the RVDT for the water to freeze and seize the RVDT shaft. But, it did not stop the armature completely. It allowed the shaft to slightly wind up, at which point it broke away, then skipped. The system overshot and because of the torsion-spring-like action of the RVDT shaft, the flight surface went into a flapping motion that every eagle would be proud of. Once the vendor redesigned the seal, the problem went away. The

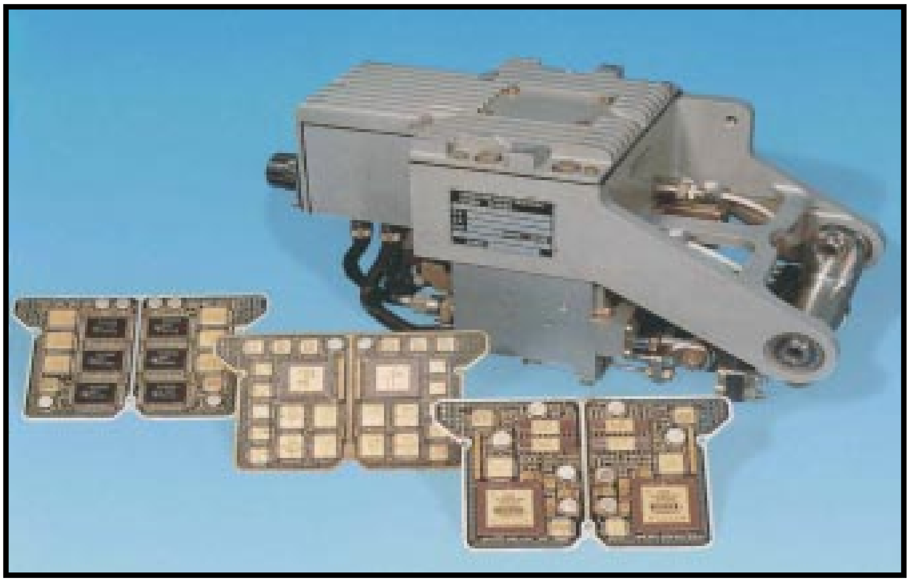

Photo 2—*In especially harsh environments, the control electronics may become a part of the hydraulic actuator. The advantage is that there needs to be very few electrical connections with the outside world. Besides power, everything else can be fiber optics. This actuator won't stop working even during nuclear explosions, which are notorious for their high-power EMP.*

possibility of catching this problem through laboratory testing was almost nonexistent.

My second example involves a control system that, after several years of flying, would generate uncommanded movements. Once the pilots discovered that the movement would happen every time they used the radio, they had great fun with it, calling it “fly-by-mike,” in contrast to the more widely known fly-by-wire. Although the solution seemed simple at the first sight, the unit was rock steady when exposed to the strongest e-fields in the test lab.

Eventually, gaps caused by corrosion and mechanical stress were discovered between the airframe and the cover where the equipment was installed. The gaps, acting like a slot antenna, effectively radiated energy into a supposedly shielded space.

FINDING A SOLUTION

Incidents like this make the DO-160D, the Environmental Conditions and Test Procedures for Airborne Equipment, a good friend. This reference consists of 25 sections, divided between environmental and electrical requirements.

In this series of articles, we’ll look at the requirements and what they mean to us as designers. Next month, I’ll take you into the meat of what the DO-160D standard is all about. You’ll quickly see why I refer to it as a friend.

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