PART II: Understanding Calibration

Traceability, Standards and Practical Strategies for Shops

BY WALTER SHAWLEE 2

Editor's Note: This is Part II of a two-part series exploring calibration of equipment. Part I in the September issue of Avionics News *focused on the necessity of calibration and repairs for accurate operations. Part II deals with calibration standards and strategies.*

Calibration always traces backward to reference items of known performance held at sites of increasing accuracy and stability. "Traceability," or what standard was used to establish the value used to set another unit, is the key here.

In the United States, this trace generally leads back to NIST (National Institute of Standards and Technology), which can be found at www.nist.gov. To see the policy on traceability, visit http://ts.nist.gov/traceability.

As defined by NIST, "Traceability requires the establishment of an unbroken chain of comparisons to stated references each with a stated uncertainty."

In Canada, this standards function is performed by its National Research Council's Institute for National Measurement Standards, which can be found at http://inms-ienm.nrc-cnrc.gc.ca/main_e.html. To see its statements on traceability and measurement uncertainty, visit http://inms-ienm.nrc-cnrc.gc.ca/calserv/calibration_services_e.html#CalibrationReports.

Virtually all calibrations are required to show the standards used in the process and their traceability. In the U.S., it is typically back to NIST, and in Canada to NRC; however, either is acceptable in either country. Your external calibration certificate on file, showing the NIST/NRC standards used, is your in-house standard's traceability back to a primary source.

LOOKING FOR A CALIBRATION LAB?
Several calibration labs are listed in the Marketplace section of *Avionics News* magazine and many are AEA members. For more information, visit the AEA's online Member Directory at www.aea.net/MemberDirectory.

Standards

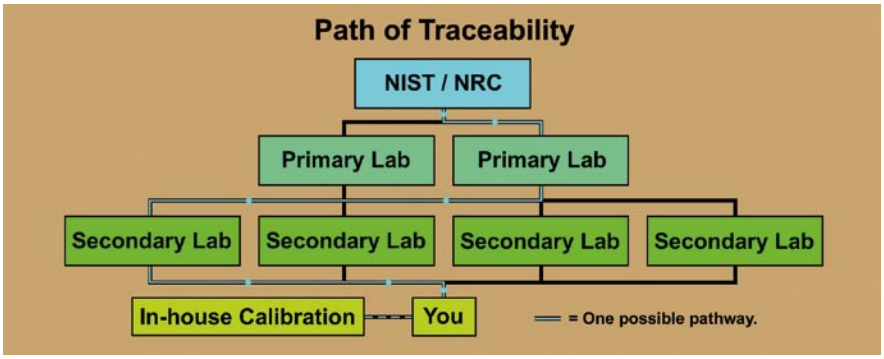
The cost of acquiring and maintaining a wide range of primary reference standards is staggering, along with the ongoing burden of qualified staff and secure, environmentally controlled facilities, plus the need for external calibration and validation of all those standards.

Even a modest calibration facility can have annual certification costs of $25,000 to $50,000, and capital/facility costs of $250,000 or more. Multi-million-dollar lab costs are not uncommon. In addition, accreditation audits to various standards add annual fees of $5,000 to $25,000, and sometimes much higher in larger facilities.

Fees for certification at government agencies and primary cal labs can be quite high, and delays (if not scheduled well in advance) can be long. Most importantly, many will only record data; they will not do adjustments to bring a unit into calibration or carry out any required repairs. They expect these steps already have been completed prior to arrival, which is a bit illogical in some instances, but can be policy.

To do calibration at your facility, you will need traceable standards linked back to some known primary references. To do any in-house calibration, they also need to still be within their valid calibration cycle. Equally important is a valid calibration procedure for the items you want to do (taken from manufacturer's data and manuals, or from government master records).

In addition, a temperature-stable environment (typically +23ºC +/-5ºC for electronic equipment and +20C +/-2ºC for dimensional and pressure) is required for the measurement transfer, along with high-quality interconnects free of thermal EMF artifacts (un-plated oxygen free copper wire is ideal). Incredibly,



plain copper telephone wire often is the ideal interconnect for DC measurements, with the fewest thermal EMF errors.

Practical Strategies

Primary calibration labs with extensive certification usually provide the traceable link needed to the master standards held by governments; they, in turn, serve secondary facilities (with varying levels of certification) with practical transfer measurements for their standards. These facilities, in turn, serve you as the customer needing equipment calibration.

Many navigation system generators return to either the manufacturer or their designated repair and calibration depots for annual calibration and repair when needed.

Make certain any item of this type you send out can, in fact, actually be done at the facility you intend to use.

It is difficult to do accurate RF level measurements below -90dBm, and only costly, specialized equipment, such as a measuring receiver, can work below these levels. Most avionics equipment testing is done below these levels, which makes accurate RF level certification especially critical and significantly reduces the number of cal facilities that can provide useful support. In addition, correct navigation modulation signals must be measurable with high precision, an uncommon general industry requirement.

In your shop, you should arrange your test equipment assets so you have the best time coverage (continuous availability) and greatest ability to crosscheck your measurements. If your best equipment has at least a 4:1 accuracy ratio to your lesser items, you might want to consider developing internal calibration for simpler items.

If you have to ship key items out (as most of us do), make certain you have rugged, well-padded shipping containers for them. Many mil-spec transit containers are available on the surplus market to protect your gear, and it is money well spent. And be sure your insurance coverage correctly protects the item in transit. You certainly don't want to discover the new $18,500 spectrum analyzer was uninsured when it returns after being crushed during shipping.

CALIBRATION Q&A

Q: Do I need to calibrate everything?

A: Yes, at least once initially, such as validating a test harness as correct and working. You might designate some items to be "Cal Not Required" or "Cal as Required," but then you never really know their status or how they impact your operation, nor can you use them in any approved process unless you have specifically allowed this. No reference, active or data display item (meter, power supply, generator or load) should ever be left outside the calibration loop, although for some low-use or known low-drift items, you might elect to lengthen the interval beyond one year.

You also can limit the use of some items marked, such as "Not to be Used for Equipment Calibration or Certification," when they are used for internal non-critical functions and never will be used to calibrate any external customer items. Marking tags of this kind should be vivid yellow, orange or red for clarity.

Picking a Cal Lab

When choosing a calibration facility, pick one with the best quality, accuracy, service and reporting, not just the lowest price.

"Paper compliance" based on price alone can be a dangerous strategy, especially if serious errors creep into your equipment from substandard or inadequate calibration, and from there to your customers.

If you are on good terms with your other local shops, you might want to compare cal results on your equipment to build up some history on different cal labs and crosscheck your own gear. Always crosscheck any item just received back from calibration, and contact the cal lab if you find anything unsatisfactory, especially if it significantly disagrees with your supplied test data.

Many people can afford a high-accuracy GPS-disciplined frequency standard, which can serve as an ongoing shop frequency reference and give an additional level of confidence to measurements. Your frequency generators and counters often can accept an external clock input, driven by this stable source through a distribution amplifier. This technique can improve frequency accuracy by up to three or more orders magnitude over the internal clock reference.

It is not always well understood that many high-end manufacturers intended for their instruments (especially synthesized generators, spectrum analyzers and counters) to be driven by a master external standard (typically 10Mhz), and the basic internal reference might be only adequate to permit basic operation. You might want to investigate this strategy for your equipment, as it also can reduce your overall calibration costs. RF generators, such as HP 8647A, 865A/B, 8657A and many HP spectrum analyzers, ben-

Continued on following page

Continued from page 67

efit from this external clock technique.

You also should be aware of the diminishing quality of many modern pieces of equipment, which might be "digital" but might not offer high stability, high accuracy or high durability. There also have been big shifts in manufacturers' product support, which might mean only three to five years of support for even brand-new items. Be certain you know the product support plan and calibration costs for any new items, and consider that some used gear can be of higher quality and at a lower price.

I am still amazed that a 30-year-old Tektronix 465B oscilloscope can be fixed or calibrated almost anywhere, and can still give excellent service, while many modern digital scopes already are completely out of support and can be fixed nowhere, not even at the factory.

Your shop equipment can be a powerful asset to you when well maintained, so consider what strategies will work best for you, and try to weed out any problem items that spend too much time in repair or cost too much to calibrate. Use the daily check technique to catch any problems before they affect customer equipment, and always protect your gear in transit. ❑

If you have comments or questions about this article, send e-mails to avionicsnews@aea.net.

CALIBRATION Q&A

Q: How often do I need to calibrate something?

A: The generally accepted interval is one year, based on the equipment specification drift called out by most manufacturers. Some items exhibit very little drift (particularly higher-end Fluke meters, such as the model 87) but might have wear and battery issues triggering failures or errors; therefore, a one-year cycle makes sense for most things. If you have a regular daily check procedure, you can justify a three-month extension window in your quality-assurance plan to allow for local timing or access issues.

Equipment does not suddenly go inaccurate on the 366th day since calibration — regular daily checks reveal far more problems than annual checks. In addition to a periodic calibration, all items must be removed from use and sent for repair as soon as any fault is detected no matter where they are in the calibration cycle.