Telecommunications Metrology

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Abstract:

Manufacturers of telecommunication equipment face what can be considered a complete set of challenges and decisions. First is product calibration and re-calibration. This affects manufacturers of end-user items such as cell phones less than test equipment manufacturers. However, both manufacturers of end-user items and test equipment share the second challenge: equipment calibration. The complexity and diversity of required equipment influences the choice of whether to set up an internal lab, out-source the support, or implement a mixed solution. Since a viable solution to the second challenge will often provide the basis for a solution to the first challenge, this paper and presentation will address primarily the second challenge.

Text:

1. Product Challenges.

   1.1. Producers of what may be called end items have some challenges for their product certifications. Cell phones, cable and satellite systems, and phone switch systems sold to consumers and businesses alike must be tested and certified prior to sale.

   1.2. End item testing must be performed to specific standards. Some of the standards are Government-regulated and some are industry standards. Examples of Government regulated standards include CE Mark regulations for Europe and requirements that electronic systems for North America be CSA/UL/TUV marked. Governments can also have their own laws act as standards. An example in the U.S. is the FDA (Food and Drug Administration) requirements commonly known as GMPs, known to the FDA as 21 CFR 820. Industry standards are typically either general or specific. An example of an industry standard that is general in nature, and is rapidly becoming the leading Management Standard in the Telecommunications world is TL-9000. This is known as a sector-specific standard in the ISO 9001 community. A group known as the QuEST Forum, a group that is composed of many well-known telecommunications companies, developed TL-9000. An example of an industry standard that is specific is the Telcordia standards. The Telcordia standards define a series of requirements for up-time, reliability, faults, testing and validation, and similar related requirements. One of the primary requirements is an up-time of 99.999%, known as the “five nines.” ISO 17025 is the international standard for testing and calibration, but is largely unknown outside the Metrology and test communities.

1.3. Some product certification can be performed using uncalibrated equipment. Certifications that do not require quantitative measurements do not require calibration. These types of tests are often digital in nature, and are qualitative, not quantitative.

1.4. Many other product certifications do require calibration however. An example, even for end-item producers, is the testing required for CSA/UL/TUV labeling. In this type of testing, the product often goes through destructive testing to ensure it is safe. There are many parameters tested, including break-down voltage and current for transformer insulation. That is, at what voltage and/or current will the insulation of the primary input power transformer fail? That is a quantitative measurement, and requires calibrated equipment.

2. Equipment Calibration Issues.

2.1. The first issue typically is a diversity issue. A single product may require only one or two items to certify, such as an oscilloscope and a DMM. If multiple types products of varying complexity are being certified and/or calibrated then the amount and mix of equipment required increases.

2.2. An example is an Optical Power Meter. The name suggests that light is fed into the instrument and that the instrument reads it directly. In fact, the Optical Power Meter is generally a fairly simple instrument and depends on Optical Detectors to produce a signal that the meter then reads. Optical Power Meters are typically certified and/or calibrated using oscilloscopes and DMMs. Some of the meters have a few extra functions that require a DC power supply and an audio oscillator. Support for equipment like this can be provided by most calibration providers.

2.3. More complex equipment, or a more complex variety of equipment, may require a more diverse degree of support. For example, Optical Detectors require a monochromator, Optical Power Meter, and standard detectors. The monochromator can be simple and fairly inexpensive or much more sophisticated and expensive. Costs for this instrument alone can range from a low of approximately $15,000 for a simple one, to a high of $90,000 for a system with full capability. Features and testable wavelength range are the driving factors for cost. This cost does not include the standard detectors, the Optical Power Meter, or the time and study required to validate the instrument as fit for use. If those figures are added, a simple system can cost approximately $50,000, and a full-capability system can cost as much as $600,000. The largest portion of that cost is the Gage R&R. Each type of detector must be validated across the intended wavelength range. A simple system may have an intended use of calibrating an SL detector at 632.8 nm (the wavelength of a HeNe Red laser), and so have a much simpler Gage R&R. For a simple Gage R&R, three operators and five detectors would be required. Each operator would run the each detector twice. That now means 30 detector runs, plus time required to distill the numbers to determine the uncertainty, and overhead amounts placed on the entire effort to accurately track costs, will add up to a significant amount of money. At Newport, we purchased a second full-capability system (we already had one), and needed to validate 22 different detectors and integrating spheres with a combined wavelength range of 180 nm to 1900 nm. A little simple math will show how quickly an effort like that can become very expensive. If the variety of products and equipment include RF testing, lasers of various kinds, EMI/EMC testing (required for emissions certifications like CE Mark), it is easy to see how the degree of required support expands radically.

2.4. Support for products and equipment can be fairly simple and inexpensive, or complex and very expensive. Supporting only a handful of oscilloscopes, DMMs, DC power supplies, and audio oscillators will often cost only a few hundred dollars per year, if the support if outsourced. Internal lab support may cost a bit more, depending on the overhead factors. A wide variety of equipment to support a diverse product offering may require tens of thousands of dollars per year, and have multiple providers, both internal and external. Supporting the equipment being used to support the products then adds another layer of diversity and cost to the support picture. Determining the means of obtaining and delivering the necessary support is the job of the Metrologist, although the QA Manager is typically given the task.

2.5. Internal calibration labs offer the benefit of more direct control over the calibration process. In theory, more immediate support is available to the manufacturing lines. The drawbacks of an internal lab include cost, and keeping the technician(s) motivated to provide rapid service. An internal lab will often support the equipment being directly used on the manufacturing lines to certify/calibrate product. The support may include both calibration and repair of the equipment. Technicians may be required to support a variety of product lines, including items produced in clean rooms or in warehouse environments. Having technicians available internally reduces the cyclic down time for calibration for manufacturing lines. Internal labs may cost more however. Although the salary may be competitive with 3rd party calibration technicians, the true cost must include the overhead factors associated with benefits and space for the lab.

External calibration labs offer the benefit of lower cost, perhaps substantially lower cost, but the tradeoff is less direct control over the calibration process and timeliness of support. External support is often the best solution for smaller companies. The key to obtaining the proper support is qualification of the calibration provider(s). This process will be addressed a bit later.

2.6. A mixture of internal and external support may be the best option for some companies. This solution maintains internal calibration support for some items, and outsources other items. The mixture of internal to external may vary depending on the equipment supported, the products certified/calibrated, unique needs such as Primary Standards, and cost factors. The keys to success include a cost-benefit analysis however basic, identification and documentation of the status of each item of equipment (internal or external support) and any unique requirements, and selection of the external calibration provider(s).

3. How to Decide.

3.1. A cost-benefit analysis should be used to determine whether to use internal or outsourced calibration, and if a mixed solution is used, help determine the proper mix. A cost-benefit analysis does not have to be an overly extensive study that results in a thesis, but should be appropriate to the amount and variety of equipment being supported and to the risk to the company. A simple cost-benefit analysis will include the wage and overhead cost of the technician(s) and will compare that cost to an outsourced solution to determine whether outsourcing or internal support is best for the company. The salary and overhead figures should be available from the financial department. An analysis this simple is typically appropriate for a simple yes/no answer for outsourcing, and typically for only a small amount of equipment, or a small variety of equipment. A more complex variety of equipment, or a significantly larger volume of equipment, and unique needs, make the analysis more complex. Identification of the variables involved, and determining how to represent the variables correctly in the analysis, is the most difficult portion of the analysis. The variables involved will likely differ from one company to another, and even from one site or department to another in a large company. Multiple departments and locations may in fact be variables. Often the financial department can be enlisted to help determine the variables, how to represent them, and even perform the number-crunching. The caveat is that as the volume and complexity of the equipment and variables—and therefore the analysis—increases, the exact definition and distillation of the information obtained must be clear and specific to ensure that a report is produced that can actually be used for decisions.

3.2. There are two portions of a study that should be present, even in a simple analysis. These are the SWOT (Strength, Weakness, Opportunity, Threat) and FMEA (Failure Mode and Effects Analysis). Each should be completed at the beginning of the analysis cycle, and again at the conclusion of the analysis before presenting the analysis to Management.

3.3. SWOT analysis is an overview of the benefits and drawbacks of the proposed decision regarding the calibration support. The benefits and trade-offs of each option described above may be points for a SWOT analysis. Opportunities for greater revenue and/or savings, and threats to revenue/savings should be listed and explored. The SWOT analysis and financial report, properly presented, will assist Management in making a decision.

3.4. The FMEA is more a nuts-and-bolts look and is meant for implementation of the decision, and troubleshooting any issues. FMEA will look at each process and point in the process, and ask what could go wrong and what the likely effect will be. Once a decision has been reached, plans can be developed for implementation that address the potential major issues, and have contingency plans for other potential issues. The FMEA can then be used to facilitate an easier implementation.

3.5. If the decision includes outsourcing, then selection of the calibration provider(s) becomes an issue. The most critical points in selecting a provider are establishing the proper standard(s), and ensuring the provider actually meet the standard(s). First is establishing the standards. Almost any proficient lab can provide adequate calibration of oscilloscopes and DMMs, unless the items are the higher end items. RF testing, lasers, very high-end systems however require much more involved support, and the selection criteria should be appropriate for the higher level of risk. The Metrologist/QA Manager may encounter problems finding providers for a calibration bid. For example, there are very few labs in the U.S. with serious fiber-optic capability, and even fewer that are accredited. If the support required is fiber-optic, then accreditation may have to become a trade-off to obtain necessary support. If accredited support is available, then accreditation to ISO 17025 should be considered as a required standard for award of the calibration contract. If ISO 17025 is required, the calibration provider must have the necessary support listed in the Scope of Accreditation, or the accreditation is not valid for that support. An on-site audit should always be performed, if possible, prior to contract award in order to verify the capabilities of the calibration provider(s).

4. Summary.

4.1. The telecommunications industry faces a broad series of challenges because of its diversity of products, equipment, and requirements. Solutions to the challenges must be solid, well-defined, and well-documented to be of value.