The SGIMM and Integrated Product Development, Test and Certification

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Keywords*:* Product development, test, SGIMM, product certification

Abstract

One of the critical challenges facing the achievement of the Smart Grid is the adoption and effective implementation of products based on standardized technologies. The US Government NIST Smart Grid Standards Roadmap is the first definitive effort to create a body of standards to deal with all critical functions needed for the Smart Grid to achieve its goals. But the gap between technical specifications and products that actually interoperate in a "plug and play" fashion is largely unappreciated and exceedingly difficult to address. The conventional wisdom in the electrical utility technology community is that a good product certification program can be sufficient to achieve interoperability goals. Such programs take years to mature and do not always achieve the desired results. This paper looks at the reality of what is required to achieve interoperability and the role of certification programs as currently designed, and describes an alternative model that integrates vendor development with the availability of standard test tools and the final certifications of products. Further, in developing the Smart Grid Interoperability Maturity Model (SGIMM)[1], test and certification metrics are a critical component in assessing interoperability maturity. This paper suggests how an integrated test and certification model can contribute a framework of to interoperability maturity assessments.

1. INTRODUCTION

IMPROVED interoperability is critical to the achievement of the objectives associated with enabling smart grid capabilities. Lessons from supply chains in other sectors indicate advancements in their maturity to address interoperability issues reap significant benefits [1]. Interoperability as envisioned for the Smart Grid is about adoption of industry standards and their implementation by vendors and their customers.

While there is a great deal of interest in writing new standards or improving existing electrical system standards, the real challenges emerge when vendors attempt to bring standards-based products to market, and customers attempt to integrate them into new or existing applications. Invariably, the creation and use of certification test programs and other methods to ensure achievement of the standardization goal are addressed inadequately, if they are addressed by the industry at all [2]. The customers and implementers of these applications often need to develop unique test and certification programs to meet their specific requirements. Historically, the conventional wisdom in the electrical utility technology community is that a good product certification program can be sufficient to achieve interoperability goals [3]. The establishment of a disciplined and thorough interoperability certification program is an essential aspect of achieving interoperable, standards-based technology, but such a program takes years to mature and may not be sufficient to ensure success. Structural issues make it extremely difficult for a formal industry certification program to achieve 100% interoperability goals [4].

The Smart Grid Interoperability Panel Test and Certification Committee has developed the Interoperability Process Reference Manual [5] (IPRM), which contributes a standardized set of guidelines for certification programs along with assistance to certification authorities for smart grid standards in implementing the IPRM.

However, even the best certification programs suffer from their structural design and positioning. Vendors view certifications as an unwanted activity that consumes engineering resources and valuable funds, and adds to the delivery schedule of products. Vendors tolerate these negatives if and when 1) their customers demand certified products, or 2) they find intrinsic value in the certification process itself in terms of improved products.

Unfortunately, the experience of numerous certification programs is that interoperability is not achieved, and customers and vendors continue to spend resources to get site-specific interoperation to occur.

By viewing development, test and certification as a continuous and valuable process, the goal of interoperable products based on specific standards can be achieved, while reducing engineering costs and schedules. The key to such an integrated program is to create and disseminate a portfolio of complete, industry-standard test tools in parallel with the development of products based on a new or updated standard. The test tools, when designed as a superset of the certification requirements for interoperability, make certification an efficient process that adds minimal costs and schedule compared to traditional certification models.

The availability of such comprehensive test tools also impacts the overall interoperability maturity of a specific implementing community by enabling a high level of test and certification achievement at minimal costs. The concepts discussed in this paper can inform the test and certification maturity measurements in the SGIMM.

2. ONE STANDARD: ONE TEST SUITE

The Smart Grid industry has made great strides in establishing and maturing technology standards that facilitate the

[1] GridWise Architecture Council "Smart Grid Interoperability Maturity Model", 30 September 2010.

interoperability of Smart Grid products. However, the development of technology standards is just the starting point. To achieve in-the-field interoperability requires a standardized set of engineering test tools integrated with a robust certification program for resulting products.

The QualityLogic experience is that a robust set of engineering test tools is as essential to successful products based on interoperability standards as are the technical specifications themselves. Further, industry certification programs are generally insufficient by themselves and need to be part of a comprehensive set of test tools and a continuous development, test and certification process.

The development and use of industry standard engineering tests for interoperability has numerous benefits. Key benefits are accelerated interoperability, shorter development and certification schedules, and dramatically reduced engineering costs.

The whole point of an industry standard is to have just one agreed upon definition of what a technology is to do and how it communicates. For instance, a standard may have a single definition of "time." Two systems that "conform" to the standard would understand what each means when it communicates a timestamp. While a standard may specify different representations of time for different contexts, it wouldn't specify two different meanings ascribed to "time" in the same context. Doing so would just cause confusion and you wouldn't really have a standard.

A real-world example was provided by the IEC 61850 UCA Working Group at their Plugfest in March of 2011 [6]. The Plugfest found that Boolean values are initialized to represent True or False. However, IEC 61850-6 is mute on the actual value that should be used. This means that values consisting of: T, F, Yes, No, Y, N, On, Off, and other permutations could all be argued to be valid. There was not a specific conformance test that had been defined for this issue, and interoperability problems were found. As it turned out, vendors were left to make their own decisions as to the interpretation of this specification, and different vendors chose different interpretations.

Why would an industry have two tests that expect different results for the same definition of "time" in the standard? To avoid such issues, the industry would want only one test result that proves that a product understands time or Booleans in the context exactly as specified in the standard or as agreed to be the common interpretation of an ambiguity.

Just like the requirements that a technical standard be very precise and only one specification exist for a standard, a set of test cases needs to be equally precise, and there should be only one way the specification is interpreted in the testing.

Figure 1 illustrates this common problem. While there is a common set of certification tests, it is a small set compared to all of the functions that could be tested. The Boolean issue identified above is not included in the certification tests, so two vendors can and do interpret the specification differently.

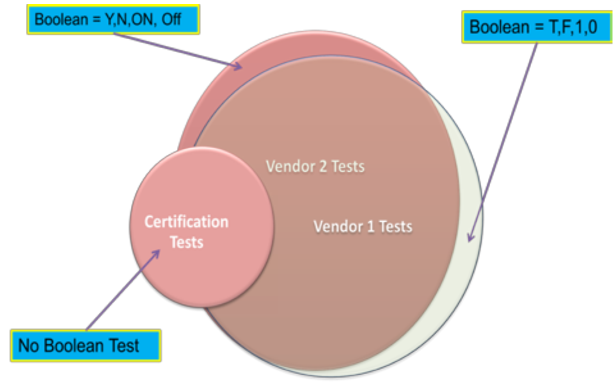

Figure 1: Interoperability issue due to differing tests.

We find three glaring problems in the efforts to enforce "standards" for products claiming to conform to a standard through certification programs. First, there may be competing test labs developing their own set of tests for certification purposes. Without an effective mechanism for ensuring that all of the tests expect exactly the same results for a particular product feature or function defined in the standard, there is a risk of differing interpretations of the specification. This can lead to very subtle differences in certifications, which in turn lead to huge interoperability headaches in the field.

The second problem is that the "certification" tests, while singular and precise for what they test, do not provide the richness, depth and type of test coverage that is needed to ensure that "compliant" products will actually interoperate in almost all circumstances. Instead, certifications generally attempt to test a subset of features and functions that are most common. This is due to the nature of certifications themselves, as well as a general lack of resources on the part of certifying bodies to create the full complement of test tools and tests required to achieve interoperability. Figure 1 illustrates this issue.

Certifications are and should be either 1) a sampling of tests that look at random features and functions rather than an exhaustive set of tests covering all features and functions allowed, or 2) a validation that the most critical and commonly used features and functions in a specification are compliant with the specification. The reasons are simple: time and cost.

The more exhaustive a certification test is the more expensive and time consuming it is. Since such tests come at the end of development, they simply delay product shipment, and the vendors, who generally fund and govern the certification programs, naturally resist overly expensive and time consuming delays to their product introductions. (After all, engineering has "certified" that the product is "compliant".)

If vendors are implementing the specification accurately, a certification that demonstrates that a subset of features and functions is compliant can provide confidence that the remaining features and functions are compliant (if the certification tests are actually a sampling of tests unknown to the vendor engineering team).

Many certifications are actually made up of tests that are well known to the vendors but represent only the most commonly used features and functions (the 80/20 rule applied by consensus). In reality, most implementations of a specification and most applications they are used for only exercise a subset of all the possible features and functions of a technology specification, so testing the common subset ensures that products can interoperate "much" of the time. It's those uncommon cases when features or functions not considered most common (and not tested for certification) are used (or when the certification test misses a subtle nuance in a common feature or function) that interoperability problems are likely to occur.

Since the actual certification tests are usually made available to the vendors ahead of time, engineering is able to ensure that the subset of features and functions tested will pass the certification tests. But since they don't have a comparable set of "standard" tests for the balance of the technical standard to use in development, there is no way to ensure that every vendor builds products that behave the same way in the non-certification areas.

This would not be much of a problem if the certification tests covered a great percent of possible features and functions in a specification. However, our experience is that certification tests likely cover just a fraction of possible features and functions. In some cases where a large percentage of potential functionality is optional and the certifications only address the mandated functions, there may be only 30% (or even less) of the possible features and functions actually tested in the certification process [7]. It should be no surprise to customers that "certified" products from different vendors do not talk to one another successfully in all aspects of an application.

The third issue with certification programs is that they only focus on conformance testing and not actual interoperability tests. Generally, interoperability testing is most productive when it is built upon a strong conformance certification program [8]. Certifying that two products will work seamlessly together can only be accomplished by some form of actual interoperability testing of the products themselves. Conformance testing increases the probability of such interoperability but cannot in itself guarantee it.

Rik Drummond, current Chair of the SGIP Test and Certification Committee, has published an excellent paper in which he shows that conformance does not guarantee interoperability [9].

3. DEVELOPMENT TEST AND CERTIFICATION

Achieving interoperable products based on a technical specification requires an industry-standard set of tests for many more features and functions than are tested in a typical certification process. These need to be readily available to the engineering development teams and put to use during the development process. Indeed, engineering teams will develop their own such tests in the absence of industry standard tests.

The product development process requires a portfolio of tests and test tools. These may vary in specifics between products but fall into three general categories of tests: 1) tests that validate conformity to requirements or a technical specification, 2) those tests which ensure interoperability with other products and systems, and 3) those which test other characteristics of a product. These "other" engineering tests are generally one of four types:

1. ***Performance***: Unless a technical standard specifies specific performance characteristics, this is where vendors differentiate themselves. These tests may include speed of action or performance, stress and load tests, and such other tests that establish performance characteristics of a product.
2. ***Security***: Some security features may be incorporated in the technical specification and will be tested as part of ensuring "conformance" to a standard. However, security features and functions not included in the standard need their own testing along with some level of "bullet proofing" – i.e., attempting to maliciously gain control of the product.
3. ***Custom Features/Functions***: Most vendors take advantage of any opportunity to develop differentiating, proprietary features and functions for a product. Testing these typically is not in the scope of a certification program, so vendor-specific tests need to be developed and used in the product development cycle.

Note that "certification" testing is not a type of development test itself because it is typically a subset of other tests used in the development process. Certifications are generally tacked on to the end of a release cycle as a marketing requirement and only minimally contribute to product engineering, depending on the breadth, depth and availability of the certification tests.

Conformance and interoperability testing typically includes a series of different types of tools and tests.

1. A ***complete Conformance Test Specification*** that addresses not only the mandatory and profile-identified options but all options and features of the specification. It should also include some error and security test case definitions. A QualityLogic test specification describes at a high level what is to be tested and how to do it but does not include the actual test cases or procedures that can be implemented by a vendor or a lab. It does serve as the definitive test specification for the standard and is an invaluable first step to standardized testing against the features and functions of an industry standard.
2. A complete ***Functional Test Suite (FTS)*** that covers the entirety of the technical specification, including the most commonly used optional features and functions as well as those used by the specific vendor, and tests for functional security aspects of the specification. This test suite is intended to cover the entire specification standard, at least those aspects being developed by the vendor, and is typically used as a "smoke test" or acceptance test when evaluating an engineering implementation of a product. A subset of this test suite can serve as test cases for conformance certification, but often the vendor-specific

options and extensions are not included in a formal certification program, nor should they be.

3. ***Lower level conformance test tools and analyzers*** for capturing actual communication traffic to evaluate conformance to the protocols in question. These still need to be driven by specific test cases or test targets that evaluate the conformance to the various aspects of the communications protocol.

4. A ***Comprehensive Engineering Test (CET)*** which is similar to the FTS but goes into much more detailed testing of all features and functions. This is truly an engineering test suite aimed at product developers and exposes areas of obscure non-conformity to the standard that may or may not warrant correction. The CET is likely to be 2-4 times more extensive and complex than the FTS.

5. ***Interoperability test suite*** or tooling which could consist of simulations of different products or applications that expect to interact with the vendor's application or product. QualityLogic has created a number of different interoperability test products that greatly speed interoperable products to market with minimal interoperability issues. As a technology matures, these types of tests can substitute for the more expensive process of formal "Plugfests" in which vendors gather together with their pre-release implementations and test and fix their interoperability in real time.

In our view, the availability of 1) a comprehensive set of conformance test cases that cover all of the features and functions of a technical specification and 2) a set of tests or methods for assuring interoperability, independent of the conformance tests, and 3) certification tests that are an intelligent[2] subset of 1 and 2 are required to ensure a set of vendors produce products that can "plug and play" or at least integrate with the ease and success expected by customers buying "certified" products. These tests must be from a single independent source (or at least controlled by a single final authority) and updated in parallel with the evolution of the technology standard itself.

The QualityLogic experience suggests that if such a comprehensive set of tests exist and is used by all of the vendors wanting to claim interoperability with a specific technical specification, the need for an actual certification program is reduced or eliminated entirely. Not that we recommend such, since there is value to both customers and vendors in having an independent "certification" that the claims of compliance are valid.

The availability of an industry standard set of test tools can facilitate the integration and improved efficiency and effectiveness of industry certification programs in several ways:

1. If the certification program is a subset of the broader conformance and interoperability set of test tools, then the preparation for certification is already embedded in the use of those tools. Pre-certification tools should not be needed.

2. To the extent that a vendor acquires and uses the industry standard test tools in the development process, it would be possible to streamline and even reduce the certification process for those vendors. Such programs as self-certification (with independent audit) and accelerated certification testing (providing a preference to vendors who use the standard tools) could provide attractive incentives to vendors to both use the tools and become certified.

3. By making a comprehensive set of tests available to vendors early in the development process, the feedback on those tests will improve the certification tests themselves (assuming they are a subset) more rapidly than introducing the certifications tests late in the process. It is not uncommon for an alliance that is responsible for certification testing to be significantly behind the vendors in developing certification tests. After all, they won't be needed until vendors have something ready to certify and have already finished their development process.

It is the combination of standardized engineering tests and certification tests that can accelerate and best ensure interoperability of products based on an industry standard. The following illustration shows how this process can work:

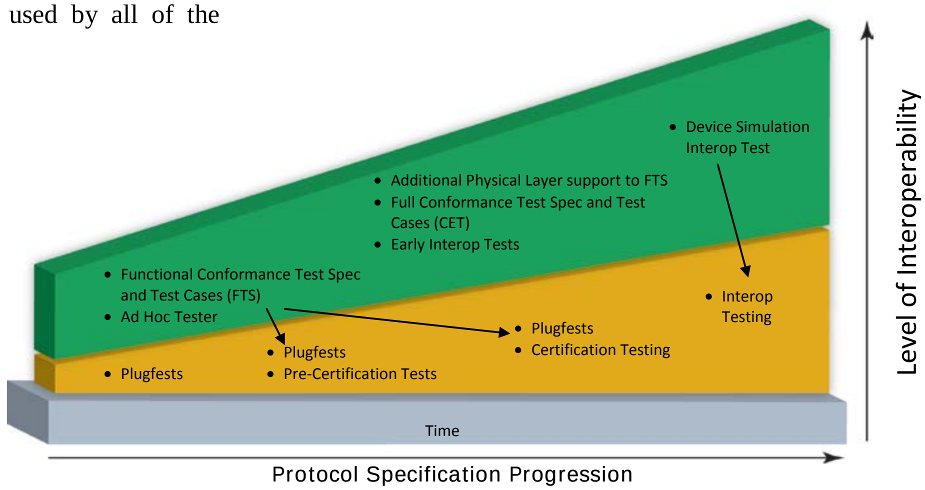

Figure 2: Relationship between Certification and Engineering Test Tools

[2] In this case the subset is designed to represent the most commonly used subset of features and functions as discussed above.

The above shows the relation between standardized functional and interoperability development tests and certifications. Subsets of the various test specifications and tests themselves from the standard development test suites become certification tests.

We should note that none of the above discussion is inconsistent with the SGIP TCC IPRM[3]. The IPRM does not assume that industry standard test suites exist. Rather, they assume that all the test planning, test cases, test management and certification programs must be done as standalone activities of an appropriate industry alliance. However, if such standard test suites as we have discussed do exist for development purposes or the industry alliance decides to invest in such tests, the cost of the certification program becomes significantly less but the program does not change in nature.

The challenge, and the main reason this model is less common, is the question of who pays for what.

4. ECONOMICS OF TEST TOOLS AND CERTIFICATIONS

One reason that so much attention is focused on Smart Grid tests and certification programs is that the technical, business and financial models for testing and certification of a standard are as varied as the standards themselves and the industry alliances that perform certifications. Models range from no formal certification programs or industry-standard test tools, to industry-funded, comprehensive tests and tools, to everywhere in between. There is no formal industry alliance or certification program for web technology, but the WiFi and DLNA Alliances invest millions each year in developing and making available standardized tests tools and tests for their technologies.

In the office products domain (printers, fax, MFPs, scanners, etc.) there has never been a formal industry alliance conducting application-level certification tests. That is due in part to the availability of comprehensive conformance and interoperability tests and test tools from QualityLogic that are purchased and used by all the vendors in the ecosystem. It is also due to the relatively few operating systems that these technologies need to interoperate with (Windows, Apple OS, Linux and a few more). The major consumer products and office products companies also invest significant amounts in developing and purchasing tests tools. The result is that the customers for these products have come to expect a high-level of interoperability – i.e., they expect to buy a printer at Best Buy or Staples, plug it in, and it works. This is a model that has succeeded nicely over the years.

In the Smart Grid domain there seem to be several different, not necessarily mutually exclusive, emerging models – i.e, some aspects of each model may exist in parallel for a specific standard:

1. A trade alliance funds the development of certification tools and pre-certification tools and owns the tools. They may then package and give or sell "pre-certification" tests to their members. This has the advantage that there is a single set of tests for certification but not more in-depth engineering tests. These are left to the individual product vendors.
2. The alliance develops the basic test specification but not the specific tests or test tools. They then ask partner test labs to develop the specific tests. This reduces the investment on the part of the alliance but has the distinct disadvantage that there are multiple tests for the same features and functions, and slight variations can cause major interoperability issues. It also means that there is not even a standard set of pre-certification tests available to vendors.
3. No certification program exists for a standard, and each vendor develops its own set of unique tests. Unless there exists a dominant vendor, such as a Microsoft, which all vendors must interoperate with, major interoperability issues can occur in this scenario.
4. A consortium of customers – i.e., utilities – funds an entity like EPRI to develop test tools for a standard. They then donate these tools to the industry and use them internally for their own acceptance testing. This has a major advantage in that customers drive interoperability. But these tools are likely to be along the lines of certification tests and will not address the breadth of tests that development needs. Further, unless there is some mechanism put in place for on-going support and maintenance to keep pace with the evolving standard, the tools will become obsolete or will be independently maintained with possible diverging interpretations of the specification.
5. The Federal government – e.g, NIST - has been active in funding various aspects of Smart Grid standardization, including the development of specific test tools and tests. This has similar challenges to a customer consortium's in terms of the scope and sustainability of the test tools. It does provide a source of funding that can jumpstart a robust set of standard test tools if a long-term structure is also put in place, such as a commercial tool vendor that can develop, market and maintain the tools.

What seems to be lacking in the Smart Grid ecosystem is the understanding and availability of the more comprehensive engineering test tools discussed in this paper.

Given twin goals of 1) creating a robust, comprehensive, supported set of standard development and certification tests and 2) optimizing the ecosystem investment in such tools, it is instructive to review a hypothetical model of the ecosystem investment and expenses to achieve these twin goals. The hypothetical ecosystem might look something like:

1. A product, based on an industry standard such as SEP 2, OpenADR V2, OpenADE (ESPI), etc., is anticipated to be used in the mass market for energy management of some sort – e.g., a Home Energy Management System, a

[3] Smart Grid Interoperability Panel, Test and Certification Committee, Interoperability Process Reference Manual, V1.0. See SGIP TCC TWIKI at http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/SGTCCIPRM, V1.0, November 18, 2010.

Building Energy Management System, an EV price-sensitive charging/ storage system, etc.

2. An alliance formed to certify compliance to the standard exists, and the typical vendor pays $5,000-$10,000 per year in member fees plus the costs of staff participation.
3. There are 50 major vendors that are developing such products based on an industry accepted technical specification for the interface to and behavior of the products.
4. Customers may be end-users of energy and/or the utilities and third parties that sell and support the products.
5. The technology is complex to the point that developing a commercial-quality, supported certification test is in the $100,000 range (assuming a standalone project independent of other test tools – a common model); developing a full functional engineering test (FTS) is in the $200,000 range; developing a comprehensive engineering conformance test (CET) is in the $400,000 range; and developing adequate interoperability tests is in the $500,000 range. A full range of engineering test tools thus cost on the order of $1.1 million to develop. These are only interoperability tests. Performance, security and other tests are outside the scope of this model but nonetheless real development costs.
6. Plugfests in the early stages of technology development might cost a vendor $5,000 per event when the manpower, travel, etc. are considered. And the organization of such events will cost someone $25,000 or so, paid for by an Alliance or participants in participation fees.

In the typical scenario where an alliance develops a certification test but the remaining engineering tests are independently developed by the vendors, the investment is significant. Assuming that vendors will not be producing commercial quality tests, they might be able to develop what they need for 50% of the estimated $1.1 million. Even so, for 50 vendors each developing these tests, the industry is investing $550,000 x 50 = $27,500,000. This does not include the on-going costs of support and maintenance which might be 5-10% of the cost of development per year or up to $55,000 per year. (It could be significantly higher depending on the complexity and changes to the specification.) This adds another $2.75 million to the overall eco-system costs of developing and maintaining engineering test tools for all 50 vendors.

They further might spend $10,000 - $20,000 a year in the certification process, including pre-certification tools, engineering time, plugfests and certification fees. This adds $500,000 to $1 million to costs but is a small amount compared to the costs of developing engineering test tools.

Suppose someone funds the development of a robust set of "standard" tools as described in this paper and makes them available on a commercial or other basis to the engineering teams of the 50 vendors. The funder could be an alliance, a government entity, a consortium of customers, a commercial test tool developer, or other entity capable of putting up the $1.1 million needed for development of the tools.

On a commercial basis with an investor putting up the $1.1 million and expecting a reasonable return on investment, the tools might sell for $100,000 for the complete set or be licensed at $25,000-50,000/year, including support and updates. For an individual product vendor, this means investing $100,000 plus annual support of $15,000 or so, or an amount each year based on annual license fees of $25,000-50,000/year. Still, when this is compared to investing $550,000 plus $55,000 per year, most vendors would purchase the commercial tools if they were available. The integrated model brings several major advantages to vendors and the industry:

1. All vendors (hopefully) are using the same standard tests, and interoperability is much easier to achieve than if they each develop their own test tools.
2. Vendors save significant investment and engineering time that can be devoted to other, higher value activities, such as tests for proprietary extensions and features. This reduces overall development costs and schedule.
3. Vendors get supported, maintained and well documented tests faster than if they developed their own. This not only eliminates a great deal of effort and cost, but the tests are likely to be higher quality than are produced internally and can accelerate product schedules.
4. The industry alliance, using the engineering tools as the basis for certification tests, is able to save costs to develop the certifications, making the costs of pre-certification tests lower or unnecessary. Further, the certification program can include reduced fees and schedule for those using the engineering tools, reducing everyone's costs for certification.
5. The industry has reduced the total investment in test tools by a factor of over 5X while increasing interoperability!

Certainly there can be variations on this model, but the basic ideas should be consistent between standards ecosystems and very attractive to the Smart Grid domain.

5. CONCLUSIONS AND RECOMMENDATIONS

This paper has explored the challenges of achieving interoperable products in the Smart Grid domain based on emerging industry standards. Our key conclusions are:

1. For every adopted technology standard there needs to be an equally robust, standard set of engineering tests for conformance and interoperability.
2. While the industry understands and supports the standards development efforts through recognized industry and international standards organizations, understanding of and support for comparable development of comprehensive engineering test tools lags significantly behind the standards.
3. Industry certification programs, by their very nature, are generally not comprehensive and are only able to test a

subset of functions and features for conformance and interoperability.

4. There are numerous business models that can address the investments needed to achieve tests the produce interoperable products. However, these need to be developed for the Smart Grid domain standards.

5. If the industry funded in some form a common set of engineering tests for a given standard, it could accelerate interoperability significantly, reduce time to market and certification and reduce engineering investments in engineering test tools by a factor of 5 or more.

Based on these conclusions, we'd recommend that industry alliances formed to certify interoperability of products based on a specific standard:

1. Find a mechanism to develop a comprehensive set of engineering tests and test tools that are independent of any one product vendor. This could be through alliance investment in in-house or contract engineering; creating a consortium of customer and vendors that invest in and own the tests; or encourage an independent third party test tool developer to invest in such tests and make them commercially available to the industry.

2. Design certification programs to utilize a sub-set of the engineering tests with the intent to integrate product development and certification as a continuous process.

3. Develop incentives in the certification process to encourage the use of the engineering test tools. This will enhance the efficiency and effectiveness of the certification program and increase both participation and interoperability of certified products.

6. APPLICATION TO THE SGIMM

The SGIMM in its current unpublished draft form [10] includes metrics specific to test and certification as follows:

Maturity Level	Test/ Certification	
Level 1: Initial	Testing is ad hoc	
Level 2: Managed	Tested to plan with results captured	
Level 3: Defined	Tests exist for community with certification	Members claim compliance to standard
Level 4: Quantitatively Managed	Community test processes demonstrate interoperability	Members claim interoperable conformance
Level 5: Optimizing	Test processes are regularly reviewed and improved	

Figure 3: SGIMM Proposed Test and Certification Metrics

There is a further set of metrics for interoperability maturity that look at the integration processes. The maturity of products based on a standard very much impact the level of achievable maturity for system interfaces. The proposed metrics are:

Maturity Level	Integration
Level 1: Initial	Integration is a unique experience
Level 2: Managed	Integration is repeatable, with customization expected
Level 3: Defined	Integration repeatable with predictable effort
Level 4: Quantitatively Managed	Integration metrics are defined and measurements collected. Reference implementations exist
Level 5: Optimizing	Integration metrics used for improvement of the standard

Figure 4: SGIMM Integration Maturity Metrics

Finally, one of the highest maturity metrics is that an "open, community" standard is adopted and used. While still being defined, it would seem that this metric would value adoption of mature, national or international standards that have associated interoperable products. Such product interoperability is likely to be achieved using some combination of test tools and certification programs discussed in this paper.

The SGIMM contemplates interfaces between systems and organizations that may be standardized to a specific community, such as an ISO/RTO region and market. But it also contemplates the use of products based on widely adopted national or international standards as catalogued by the SGIP and NIST. In either case, the framework described in this paper is useful in determining the maturity of the interfaces being assessed by the SGIMM.

At a high level, several questions or data collection items are suggested by the framework, including:

1. In demonstrating that community test processes achieve interoperability between systems or products, which of the following types of tests are documented and in use:
    a. Conformance test based on the interface specification (either adopted standard or community-specific specification)?
        i. Does the Conformance test address all of the functions specified?
        ii. Is it used by all vendors or participants in integrating the system?
    b. Certification test that is a subset of the conformance test suite?
    c. Interoperability testing in some form distinct from conformance tests – e.g., plugfests, simulation of "golden" reference implementations, simulation of real applications, other?
2. Are certification conformance tests conducted by an independent third party with documented results?
3. Are test cases for conformance and interoperability regularly reviewed and updated?
4. Does the community use the process of certifying products and systems as conformant and interoperable to

provide feedback to the organization maintaining the standard, as well as the organization maintaining the test cases?

There are more such questions that can be useful in establishing the maturity level of the test/certification metrics for the interface or community being assessed by the SGIMM. The framework outlined in this paper can serve as a valuable tool in developing the SGIMM assessment tools.

7. SUMMARY

This paper has proposed a framework for achieving interoperability between products based on a standard technical specification. The framework envisions industry-standard tests at least as comprehensive as the specification itself. Certifications are based on a subset of tests used by all vendors and greatly improve the overall efficiency and economics of the industry standardization process.

Further, the framework can be a valuable tool in development of the SGIMM, informing the assessment process and questions related to test and certification as well as integration metrics.

8. REFERENCES

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[3] See, for instance, the NIST Solicitation SB1341-10-RP-0044, May 10, 2010, "Recovery – Smart Grid Interchange Analysis and Standards Conformance Project."

[4] See, for instance, the unpublished input to the SGIP TCC Work Groups 3 and 4 by Rik Drummond, Stuart McCafferty and Aaron Snyder, Version 1.0, dated May 13, 2010.

[5] Smart Grid Interoperability Panel Test and Certifications Committee "Interoperability Process Reference Manual, Version 1.0", November 18, 2010.

[6] UCA 61850 User's Group, March 2011 Paris Plugfest. See report at http://www.ucaiug.org/IOP_Registration/IOP%20Reports/IEC%2061850%20IOP,%20Paris,%20France%20UCAIug-63-111Rv1.pdf (login required).

[7] Based on an unpublished QualityLogic evaluation of a specific certification test specification for a subset of ZigBee SEP V1.

[8] See, for instance, the Smart Grid Interoperability Panel, Test and Certification Committee, "Interoperability Process Reference Manual, V1", page 5.

[9] Rik Drummond, The Drummond Group, "The Probabilistic Correctness of Conformance and Interoperability Testing: *The Probabilistic Conformance & Interoperability Correctness Theorem*", 2009

[10] Smart Grid Interoperability Maturity Model, 25-29 July 2010. IEEE Xplore Digital Library at http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=5589785

Biography

James Mater founded and has held several executive positions at QualityLogic, Inc. from June 1994 to present. He is currently Co-Founder and Director working on QualityLogic's Smart Grid strategy, including work with GWAC, the Pacific NorthWest Smart Grid Demonstration Project and giving papers and presentations on interoperability. From 2001 to October, 2008, James oversaw the company as President and CEO. From 1994 to 1999 he founded and built Revision Labs, which merged with Genoa Technologies in 1999 to become QualityLogic. Prior to QualityLogic, James held Product Management roles at Tektronix, Floating Point Systems, Sidereal and Solar Division of International Harvester. He is a graduate of Reed College and Wharton School, University of Pennsylvania.