Reduce Costs and Increase Quality with Information Exchange Standards for Manufacturing Quality

John Horst, NIST

Information Exchange Standards: What value do they bring?

Information exchange standards enable common activities: bring a notebook computer anywhere in the world and one will quickly and cheaply find a wireless Internet connection — all due to the presence of globally-adopted standards for wireless communication. On the other hand, bring many U.S. cell phones overseas and you will spend frustrating amounts of time and money before you can finally call your friends and colleagues again — all due to the absence of globally-adopted information standards for cell phones.

Like cell phones users, quality professionals suffer from the absence of globally-adopted standards for the exchange of information between software products. Common travails include:

- Incompatible, incomplete, or incorrect CAD (Computer-Aided Design) data
- Incompatible measurement programs
- Inability to add new measurement system components because they are incompatible or integration is too costly
- Incompatible, incomplete, or incorrect quality measurement results impeding accurate reporting and analysis

These incompatibilities and impediments are accompanied by software translation costs, program rewrite costs, an unnecessary proliferation of hefty software license fees, loss of new technology capabilities, and sizeable integration costs.

The cost of translating quality measurement results alone is in the range of $5 Million per year for SPC (Statistical Process Control) North American software vendors[1]. But this is trifling compared to costs in the CAD domain. "There are probably about 180 companies in the US alone providing CAD migration [translation] services, representing a market of about $2.3 Billion US, $5.5 Billion worldwide.[2]" Translation is a completely non-value added cost, since translation is unnecessary wherever there is a globally-adopted standard.

Information exchange standards will solve the information incompatibility problem with a modest investment of time, effort, and patience – all without the high costs associated with other approaches. This simple claim about standards is commonly met with concern and honest skepticism: Doesn't it cost lots of time and money to develop and maintain standards? Isn't standards development dependent on wide user support for success? What exactly are the approaches to solving the language barrier other than the standards approach? Why do you claim other approaches are inferior to the standards approach? Will information standards hamper vendor competitiveness and technical innovation? Is it hopeless to expect competing interests to agree on a single information exchange language? Will the information standard exclude information not required by a single (powerful) vendor? Will the information standard be incomplete? Will the information standard be developed too slowly? Who will pay to get this work done? These are legitimate concerns, and before we are done, we hope to adequately address each one and persuade the reader of the value of information exchange standards.

The incompatibility problem for quality measurement systems

The information necessary to ensure product and process quality on the shop floor consists of many different types of information – measurement equipment commands, dimensional measurement results (point clouds, scanned points, probe points, portable device data, etc.), general quality measurement data (measurement value,

1 This estimate is for SPC software support to all industries, not just the automotive industry, and does not include quality measurement data format translation costs borne directly by OEMs and their tier suppliers, which could be substantial. The data forming the basis for the estimate was gathered by the author from several key SPC vendors in 2007.

2 David Prawel, Longview Advisors on www.3dubiquity.com on 21 Nov 2007

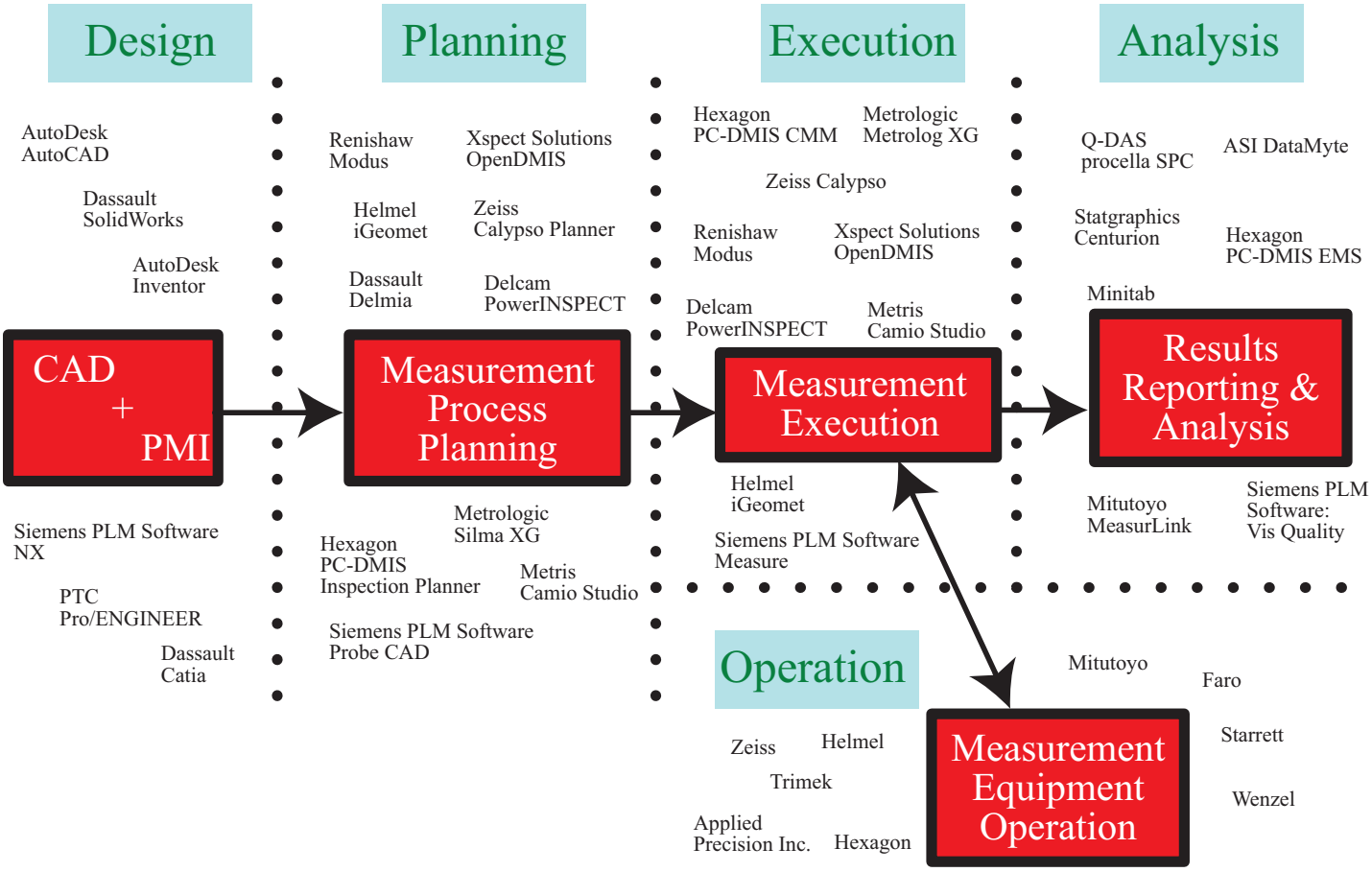

Figure 1: Measurement-related activities are shown in the five different boxes (PMI = Product Manufacturing Information). Example vendor products performing each particular activity surround that activity . Nearly every vendor product reads and writes the same underlying information in a unique format or language. Therefore, without translation, there is no interoperability if passing information to another vendor's product.

date, time, lot number, part IDs, etc.), measurement equipment types (CMMs, in-line gauges, hand-held gauges, white-light scanners, laser trackers, etc.), measurement process plans, part geometries, feature geometries, feature dimensions and tolerances.

What activities produce and consume this information? Manufacturing measurement can be broken down into the following set of distinct quality measurement activities, shown in Figure 1.

- Product Design (producing CAD + PMI (Product Manufacturing Information))
- Measurement Process Planning
- Measurement Plan Execution
- Measurement Equipment Control
- Product Quality Analysis.

We are not concerned with the standardization of the internal workings of these activities – that is where the vendor distinguishes his product – nor are we concerned with the exact boundaries of these activities. However, we are concerned with the standardization of measurement information at the interface between these activities. Think of it this way: even though a novelist has much freedom on how to define and construct a story, there are strict standards (grammar, spelling, meanings of words, etc.) on the language employed to communicate the story to his or her reader.

The current market offers a wide variety of product offerings: quality measurement equipment, quality results analysis, measurement process planning, measurement program execution, and product design. A multitude of products are currently available to perform each activity, shown in Figure 1. Each product claims some unique-

ness or superiority in the performance of its activity. This provides freedom and choice to users.

However, there is a downside to the abundance of product choices – language barriers abound. Each product reads and writes the same information communicated by its competitors, but in its own unique language. Unless neighboring products come from the same vendor, costly translation is required, and translation is completely non-value-added. As if that weren't enough, translation diminishes information quality.

Solving the incompatibility problem

Each quality software application and measurement equipment product speaks its own unique language. Unless translators are written, the product from one vendor will not communicate at all with products from other vendors. This situation is obviously unacceptable. Therefore, to satisfy user requirements, equipment and software vendors spend countless hours making sure their products can speak and interpret the language of all other vendors with whom they must communicate. Much time and money are spent on these non-value-added activities; product quality is lost. All this is at the expense of improving product and process, along with loss of competitive advantage.

End users and tier suppliers have long been aware of the information incompatibility problem. It must be solved. Otherwise, we can't move our data and still be free to choose any product. But do we have to suffer with endless information incompatibilities? Are we doomed to waste money and suffer quality losses?

As end users and tier suppliers experience the incompatibility problem, three solutions have emerged: translation, single-vendor, and standards. Let's describe each solution and examine the costs and benefits of each.

The translation solution

Many end user corporations cannot or will not mandate either a suite of standards or a single suite of single vendor products enterprise-wide. In this case, in order to maintain communication between disparate software, format translation must be performed by the vendor, the end user, or both. The translation solution typically involves no corporate-wide decision; it happens by default; it's a bottom-up solution. The translation solution is an effort to resolve incompatibilities one incident at a time or one vendor-to-vendor combination at a time.

When end users do the translation themselves, they generally build translators wherever incompatibility exists. For example, they may possess an older product with an old interface language, neither of which is supported by the product vendor. In such cases, it is common that little or no portion of each individual translation effort is used to resolve other incompatibilities. Not surprisingly, this solution can be very costly and generally lacks foresight.

Since the information incompatibility problem has been around for such a long time and since the problem must be solved, the great majority of vendors develops and maintains translators (internal to their products) one for each vendor's product with which it must communicate. As can be seen from Figure 1, the number of required translators goes up geometrically for each appearance of a new vendor product.

The single-vendor solution

Due to the burdensome cost of the translation solution, end users have lately been requiring the use of a single vendor per activity throughout the entire corporation. An illustration of a single-vendor solution can be seen in Figure 2, in which we ask you to imagine that only one of the vendors per activity in Figure 1 performs the corresponding activity in Figure 2. The single-vendor solution is a very common solution to the incompatibility problem.

As an example of the single-vendor solution, users may require "native file formats" (i.e., proprietary interface languages) from their suppliers. This provides a "solution" for the end user, but incompatibility is not solved for the supplier, who typically must support several end users, each with different product requirements. Costs borne by the supplier, such as additional training, license fees, and data translation, are simply passed back to the end user, through higher product costs. ***The end user simply shifts the incompatibility problem on to their tier suppliers, which the end user ends up paying for anyway.***

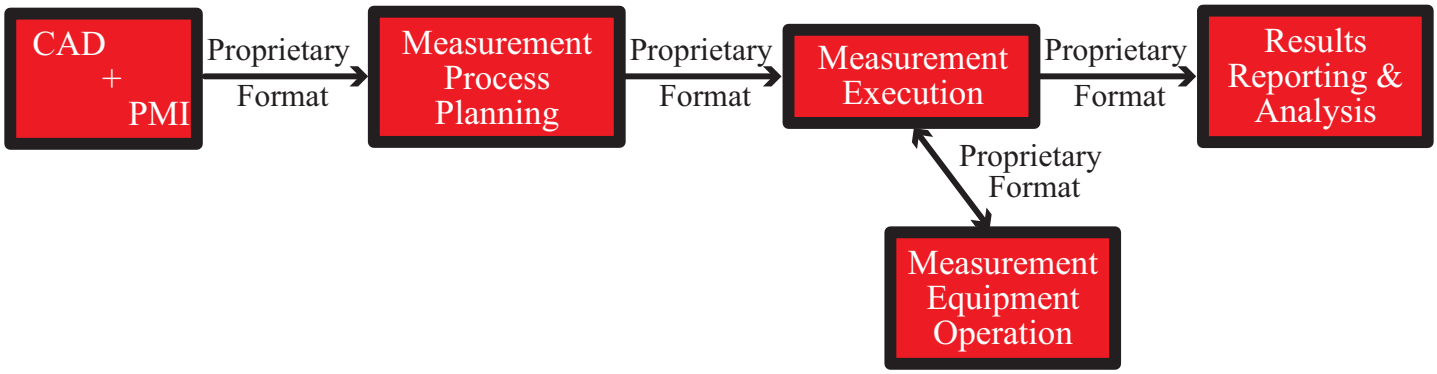

Figure 2: The single-vendor solution has only proprietary languages defining the information between measurement-related activities.

The standards solution

The standards solution looks just like Figure 2, except that a standard language is used at each interface instead of a proprietary language. With a globally-adopted standard language at the interface, an end user can easily swap in and out any vendor product at any activity.

The standards solution delivers benefits only to the extent that those standards are correctly, completely, and unambiguously defined and implemented. Both compliance and interoperability tests are required. Figure 3 illustrates the essential elements to standards success.

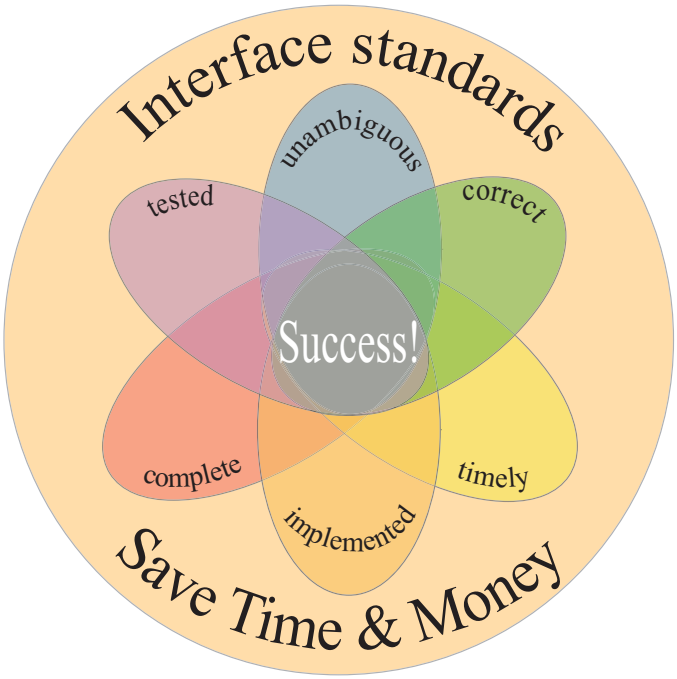

Figure 3: Information standards will save everyone time and money to the degree that those standards are correct, complete, timely, tested, implemented, and unambiguous.

Benefits of single-vendor and translation solutions

The pain resulting from information incompatibility problems can be severe. We can't move our data correctly and completely from one important activity to another. The clock is ticking and time is money. The translation and single-vendor solutions offer what may be a quick fix.

End users and tier suppliers need not consult with a standards committee of peers to solve their information incompatibility issues. They can either fix the immediate problem themselves or fix it with the help of a single knowledgeable vendor (the translation solution). They might take a somewhat longer term view and require a network of one vendor per activity corporate-wide or division-wide (the single-vendor solution).

Enterprising and knowledgeable vendors are understandably willing to solve incompatibility problems to meet the most demanding schedule. Individual companies are commonly more responsive than standards committees, as long as you are willing to pay the price, and that price is very high, as we will see in the next section.

Costs of the translation and single-vendor solutions

Non-value-added translation

With the translation solution, each vendor on one side of each interface must "speak" the proprietary lan-

guage of every other vendor on the other side of the interface, if that vendor expects to service all potential customers, which can be a substantial cost to each vendor. This cost is either passed on to the end user or else borne directly by the end user. For example, metrology process planning software products commonly support as many as ten different native CAD file formats. This support is also a constantly moving target and the cost of such maintenance is substantial, see Figure 4. Commonly, large end users solve the translation problem by requiring that all their tier suppliers "speak" to them via a single native CAD file format. Tier suppliers counter that such a "solution" is costly to them, since they must support a variety of end users, many requiring different native formats.

The author knows of an automobile manufacturer that transferred all operations for a particular vehicle model to a different facility. The transfer required use of measurement execution software from a different vendor. All the measurement process plan programs developed at the old location were now completely obsolete at the new location, since the new system required its own proprietary language. Labor-intensive data translation efforts were required, including overtime. The schedule for the transfer of operations to the new location was so aggressive, that the translation work was not completed prior to launch of the new operations. Critical first lots of vehicle parts and assemblies in the new operation escaped the scrutiny of dimensional inspection, leading to degraded product quality and increased in-warranty repairs.

Loss in quality

Translation is rarely perfect, particularly when you must fully and correctly translate the language of a competitor. ***Imperfect translation often results in a loss in quality.***

Best-in-class constraints

When a company chooses the single-vendor solution and a new and appropriate technology is offered by another vendor, the company is constrained to some degree in the adoption of the new technology. ***The integration of the new technology into the single vendor network may prove to be very costly.*** The author knows of an end user in just such a situation, who wished to integrate a new sensor into his single-vendor's measurement equipment. The equipment vendor was willing to integrate the new sensor, but the quoted price was equal to buying an entirely new measurement system, including the cost of the sensor.

Agility constraints

A single-vendor company desiring to move to a new vendor (due to corporate mergers, for example) will incur a substantial cost no matter whether the company moves to the new vendor or not. For example, if an end user has measurement programs (process plans) in proprietary format, may find himself between a rock and a hard place, given on the one hand the great cost involved in translating all the part programs to the new proprietary format, and on the other hand, the cost of not making the switch. Not making the switch may mean going back to pencil and paper or spreadsheets (very common) or paying for format translation.

Reduced competition

Because of the commitment to proprietary formats in the single-vendor network, competition between vendors is unavoidably limited. ***The lack of competition between vendors keeps prices high.***

Reduced innovation

The single-vendor solution constrains competition between vendors and lack of healthy competition typically increases product and service costs and also reduces innovation, since the smaller, innovative vendor is commonly not chosen as the single vendor. Furthermore, non-value-added costs tend to drain emotional and intellectual energy as well as expending time and money, which can also stifle innovation.

Increased training and license fees

An end user requiring proprietary formats from his suppliers simply passes the incompatibility problem on to his suppliers. Actually he only thinks he is passing on the problem, since he bears the cost indirectly. If a tier supplier must support multiple end users, he must pay regular software maintenance fees and training costs for sometimes a wide variety of vendor products. For sophisticated design and process planning software, these

costs are substantial…in the hundreds of thousands of dollars. There are translation and quality costs, as well, as mentioned above.

Unnecessary software development

Until now all the costs due to the single-vendor solution described are those directly borne by either the end user or tier supplier. However, the equipment and software vendor also has substantial cost. ***It is not uncommon for a single metrology product vendor to have to speak the languages of more than sixty different proprietary products.*** This is also an ongoing cost to the vendor, since those proprietary languages are constantly changing. This significant software development cost to the vendor is again ultimately passed on to the tier supplier and end user. For instance, it is common for measurement execution software vendors to maintain interface translators for over sixty different dimensional metrology devices. What is more, each of these proprietary languages is constantly changing, requiring each vendor to update their translators frequently. Legacy systems require that translators be maintained for multiple versions of the same product.

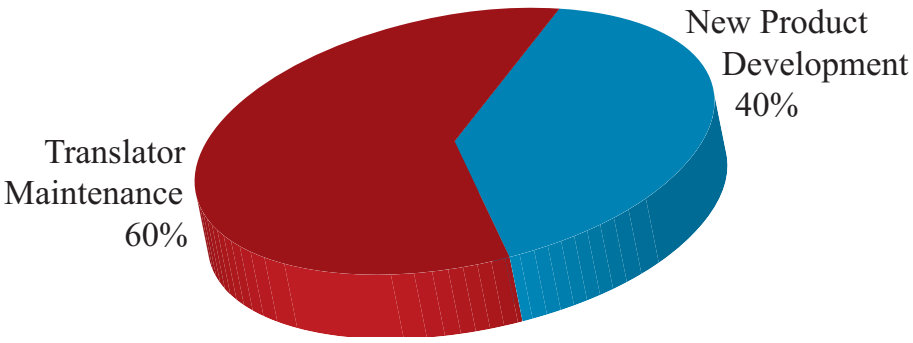

Figure 4: Vendor software development costs

This activity takes a large portion of the vendor's software development budget, up to 60% (see Figure 4), and the activity is completely non-value-added. This development cost is passed on to the end user in terms of software maintenance fees.

Proprietary license fees

It is common for measurement process planning and execution software vendors to be required to pay a substantial fee to the CAD software vendor for the rights to their data through a proprietary interface (sometime called a "direct CAD interface"). A particular measurement process planning software vendor pays a particular CAD vendor for the "direct CAD interface" an amount equal to 20% of the cost of every seat of his product, and he is, of course, required to have direct interface with several other CAD vendors, including support for multiple versions from the same vendor. This is in addition to his already substantial software development costs required to maintain the direct CAD interface.

Information access fees

It is also common today for users to enter manufacturing data into some software product and then either have no further access to this information (except visual) or be required to pay a fee for access. The most common example here is GD&T (geometric dimensioning and tolerancing) information and PMI (product manufacturing information), which commonly cannot be accessed, except visually, after entry into the software.

Product delay

Very expensive product delays and lost consumer confidence can came from interoperability failures. In 2006 news came announcing the costly delay of a new commercial airplane model of a well-known aerospace corporation. The product launch delay was expected to precipitate losses to the company projected at $6.1 Billion over the three years following 2006. Losses in new orders and corporate image would be in addition to this amount. To what can this delay be attributed? Different divisions of the corporation were using different, partially incompatible versions of CAD software from the same vendor. It was discovered too late that important design information was lost in the data transfer from one version to the other. The required manual translation of this important data turned out to be a root cause for the delay.

High dependence on vendor viability

Committing to a single vendor network substantially increases risk, since the end user is held hostage to the economic and management vicissitudes of the vendor's corporation. Several end users have suffered loss when, having chosen the single-vendor solution, a vendor in their single-vendor network suffers economic collapse, in which case, the end user can suffer greatly under the lack of support for the software product they have invested so much in training, measurement program development, and data translation. Another common scenario is where a vendor in the single-vendor network is acquired by another company and the product support is weakened, the product is taken in a new direction not beneficial to the end user, or the two products are merged into one.

Benefits of the standards solution

When properly developed and maintained, the standards solution has none of the unnecessary costs associated with the single-vendor and translation solutions. This alone is sufficient grounds to select the standards solution over all others.

If one were to pick a single word to best describe the benefits of the standards solution it might be "freedom." The end user and tier supplier are free to choose best-in-class or best-in-value among the full range of technology options, if those product options comply with information exchange standards. They are free to enter into mergers with other corporations who use entirely different vendors for the same measurement activities. They are free to move operations to different facilities without concern for retranslation, loss in quality, and lost time. They are free to make any changes to any system, without concern for any non-value-added cost. They are free to spend resources on things other than unnecessary training, maintenance fees, and license fees. When vendors are standards-compliant and because the end user and tier supplier are able to select freely among all options, a freer and more competitive environment between vendors will emerge, with accompanying lower prices. The end user and tier supplier are free to use the standard anywhere they wish without payment of royalty fees as is so common with non-standards solutions.

Another word to describe the benefits of the standards option is "innovation." Standards enable a level playing field for all vendors, and a level playing field enables healthy competition. Lack of healthy competition reduces innovation, since the smaller, innovative vendor is commonly excluded. Therefore, standards enable innovation. The large savings of time, money, and frustration that accompany standards implementation will spur investment in new technologies, trends, and possibilities.

Another major advantage of the standards solution is that there are greatly reduced copyright and patent problems than are found with the single-vendor and translation solutions. Once anyone has legally purchased a copy of the standard, they may implement the standard in any number of products without additional cost, such as is found in the single-vendor and translation solutions.

Costs of the standards solution

The key costs involved in the standards solution are that 1) leadership and support of standards organizations by end users and tier suppliers is essential, 2) there is some risk of copyright and patent problems, 3) the standard must be developed and implemented correctly, 4) the standards solution may take more time (than an single-vendor or translation solution) to bring "on-line" and maintain, and 5) the standards solution may take more time (than a single-vendor or translation solution) to bring "on-line" and maintain.

Weak end user and tier supplier support

A large number of end users and tier suppliers either do not understand the value of standards, do not believe that the gains are worth the investment, or the gains are not practically achievable. Furthermore, participation in standards efforts by tier suppliers is even scarcer. This is remarkable, considering that tier suppliers sometimes suffer from information incompatibility more than anyone.

End users and tier suppliers must lead and participate in standards development efforts, but equipment and software vendor involvement is also essential for the success of the standards solution, since vendors typically

understand the details of the information better than any end user or supplier. Happily, user involvement naturally encourages broad vendor support and participation.

Ultimately, end users and tier suppliers must require standards compliance in their corporate purchases. They must promote the standards cause at various public forums, such as quality trade shows, conferences, and trade publications.

Copyright and patent risks

Participants in standards efforts (usually vendors) sometimes claim copyright and patent rights over the content and/or implementations of information standards, which can imperil the broad acceptance and use of the standard. Vendors normally enter into standards efforts with the understanding that there will be no royalty or license fees paid to another vendor for use and implementation. Standards organizations commonly have legal tools in place to minimize these risks, highlighting the importance of participation with stable standards generating organizations.

Slower development and maintenance

Because a standard is developed and maintained by committee, it generally takes more time to develop, than a proprietary solution by a single vendor. This problem is made more acute during challenging economic times, since committee members find it harder to justify standards committee involvement. However, once a standard exists, updates and enhancements can occur more rapidly for common benefit to the industry.

Deficient standards development

The standards solution delivers benefits only to the extent that those standards are correctly, completely, and unambiguously defined and implemented. Both compliance and interoperability tests are required. Figure 3 illustrates the essential elements to standards success.

Conclusion on costs and benefits

The standards solution stands out as more forward looking and beneficial in the long term than the translation and single-vendor solutions, which have many serious and long term costs not shared by the standards solution.

There is a small but strong group of end users worldwide who are committed to the standards solution on principle. They see the simple analogy to human communication, knowing that the proliferation of multiple human languages is always costly.

Many end users and tier suppliers have committed to the standards solution only after experiencing firsthand the high cost of data incompatibilities resulting from the translation or single-vendor solutions: lost time, lost quality, lost agility, and non-value-added training, translation, and licensing fees.

End-user leadership is critical to successful standards. However, the level of end user involvement/leadership required is quite minimal. Investments include cybermeetings about once every few weeks, two or three face-to-face meetings a year, and perhaps two extra hours of work per week.

single-vendor and translation solutions have a multitude of high cost items over the long-term, but may provide an integrated solution sooner than the standards approach. Although standards have reduced costs in the long run, there may be delays bringing the standard on-line and maintaining it, since standards require some level of consensus. However, the standards community is attempting to respond to these delays with new standards development models, one of which we discuss in the next section.

A new model: accelerated standards development

The slow speed of standards development has historically been the major drawback of the standards solution. The manufacturing quality industry has responded since May, 2000 with a faster track to standards. With the support of the whole industry, the idea is to commission a small group of key users and vendors to write and implement the information exchange standard, not as a “standard” in the formal sense (i.e., following strict participation and document review rules, which tend to delay development), but as a “specification,” which is not

constrained by any standards development rules.

The DMSC, the AIAG Metrology Project Team (MEPT), and the I++ group are all attempting to follow this model. Once a specification shows unique and important value to the worldwide market and is reasonably mature and tested, it is released to an organization like the DMSC, who has manufacturing quality expertise as well as ISO and ANSI accreditation. The standards organization will progress the specification to a formal standard and maintain it. The standardization process is critical, since it ensures input from interested vendors not participating, for whatever reason, in the specification development process. The standardization process is also critical, due to the rigorous rules laid done by groups like ANSI and ISO which ensure high quality standards.

The DMSC is an important element of this new model. It is the sole maintainer of DMIS, which is the most widely-used and most successfully implemented measurement information exchange standard worldwide. Most CMM metrology systems read and write in DMIS, albeit at varying level of compliance. Many companies such as John Deere have standardized their entire metrology process using DMIS as the conveyor of information. The DMSC is also the only ANSI-accredited manufacturing quality information exchange standards body worldwide with a fast-track to ISO standardization.

How are standards developed? Define, write, implement, and test!

…define the information at the interfaces

Organizations like the DMSC, the AIAG MEPT, the I++ Group, and the IA.CMM are repositories of hundreds of years of metrology experience, both from a vendor and user perspective. They well understand the nature of this information and are well equipped to define it, both correctly and completely. Standards experts from the National Institute of Standards and Technology (NIST) are useful at this phase to help with completeness and correctness through validation tests.

…write a computer-readable standard for that information

Information needs to be defined unambiguously for it to be useful as an information exchange standard. In order for the standard to be useful, there must be no allowance for an implementer to interpret the meaning of the standard any way they wish. Otherwise, every implementation of the standard will effectively be a new proprietary specification. Use knowledgeable users and vendors to define and record the information.

…implement the standard

The Esperanto language (see www.wikipedia.org/wiki/Esperanto) is an example of an unsuccessful standard, not because it is incorrect, incomplete, or ambiguous, but because it has not been widely implemented. To succeed, a standard must be widely implemented.

Though not necessary to the success of a standard, it is enormously helpful to implement the standard concurrently as it is being defined. This is will do at least two things, 1) help gauge the support it has from users and vendors and 2) help ensure that the definition of the standard is well grounded in the "real world" from the start.

…write and use compliance tests to test implementations

An unambiguous, complete, and correct standard is no assurance that any vendor's implementation will correctly and completely implement a standard. This is because information exchange specifications and standards are still being defined in a human language, implying that no computer can currently read a specification and automatically generate a compliant implementation. Instead a human engineer is required to interpret/decode the specification document when performing an implementation.

Therefore, compliance tests are required that will verify the completeness, correctness, and unambiguity of an implementation. These tests are software applications in themselves and can be used by vendors to verify the level of compliance of their own implementations. An example view of the operation of a web-based compliance test for implementations of the Quality Measurement Data (QMD) specification is shown in Figure 5. This is an excellent role for NIST. Several test suites for different standards have been generated at NIST and are available to the public to verify the compliance of their implementations for various specifications and stan-

dards.

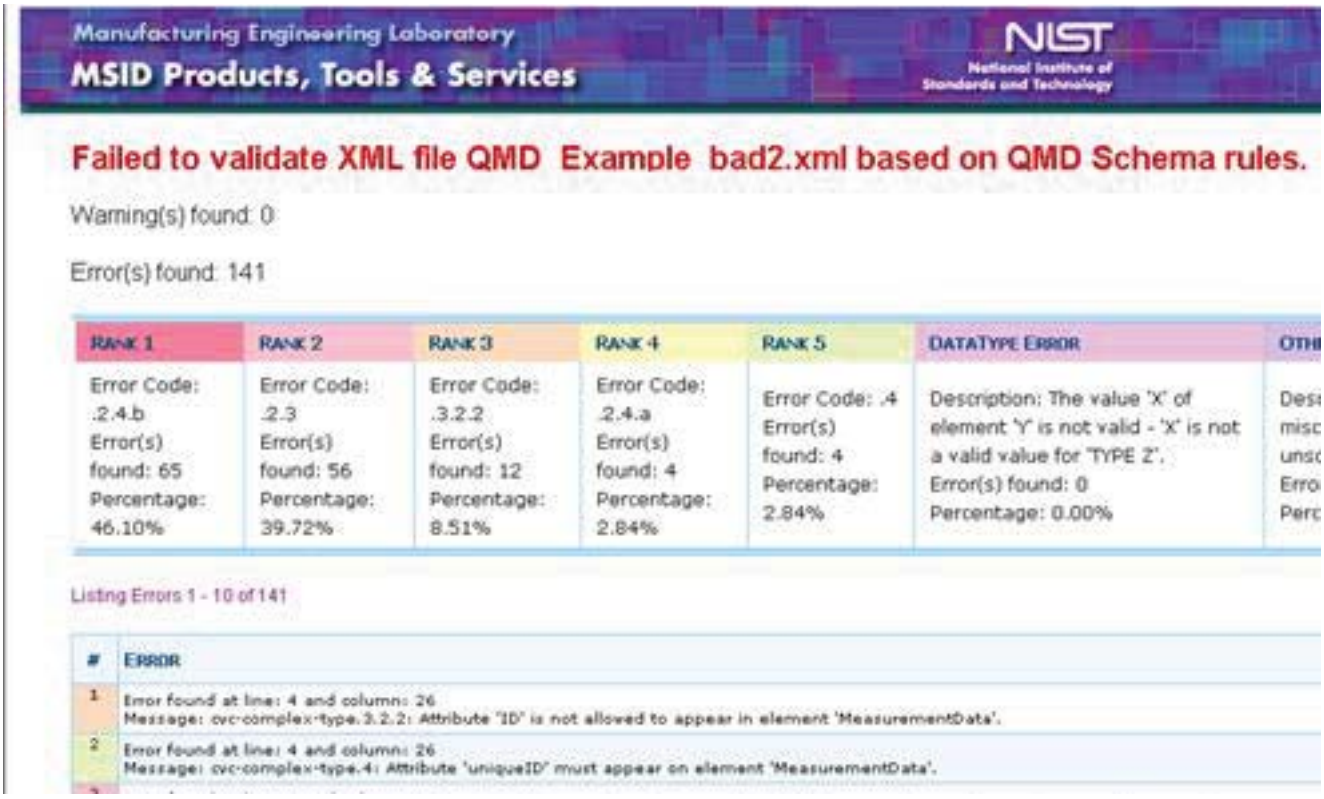

Figure 5: An example of a compliance test (generated by NIST) for an implementation of the Quality Measurement Data (QMD) specification. The application is web-based, allowing the simple uploading of a QMD implementation. This example shows an implementation that failed validation. Detailed statistics on the number and types of errors in the implementation help the implementer to quickly bring their implementation into compliance with the QMD specification.

Common objections to the standards solution

Objection 1: "Information exchange standards hamper vendor competitiveness and technical innovation."

An information exchange standard defines the information passing between key activities (design, planning, execution, operation, and analysis) and does not define how those activities are to be accomplished. Furthermore, boundaries do not greatly vary between activities among vendors. Generally, there seems to be an underlying logic to the information boundaries as they have emerged (illustrated in Figure 1 and Figure 2), having to do with the nature of the information. For example, the definition of geometry, features, dimensions, and tolerances as an output of the design activity, and input to the process planning activity, is virtually universal across all vendors (notwithstanding the fact that there is an important, ongoing, and serious discussion as to the exact meaning of these items). Neither competitiveness nor innovation are hampered, since there is general commonality about the boundaries between activities, and activities themselves are not part of the standard. Any new information required can be added to the standard in subsequent versions of the standard. Vendors can distinguish themselves largely on how they perform a given manufacturing activity.

Objection 2: "It is hopeless to expect competing interests to agree on a single interface language."

End users and tier suppliers are usually not concerned with the particular language used to define and transfer

data, as long as that language is unambiguous, correct, and complete. What they desire is interoperability, freedom of choice, and free access to their information. As long as end users and tier suppliers lead these efforts, there is good hope of agreement to a single information exchange language.

Objection 3: "A group of powerful vendors will create a competing standard or control contents of an existing standard."

Several examples of this problem can be found in the history of standards development, including competing groups causing a stalemate on a standards committee. Intelligent leadership and guidance from knowledgeable end users, tier suppliers, and other standards experts can help avoid this pitfall. The fact that the standards process allows smaller vendors to have an equal voice on standards committees also mitigates the influence of powerful vendors.

Objection 4: "The information standard will be incomplete."

This also can be a problem, as is exemplified by the Initial Graphics Exchange Specification (IGES) standard (see www. wikipedia.org/wiki/IGES), which is a useful but incomplete format for representing part geometry. Again, end user and tier supplier involvement will overcome this barrier.

Objection 5: "The information standard will be developed too slowly."

A combination of increased end user and tier supplier involvement and the new accelerated standards development model should overcome this objection.

Objection 6: "Several large corporations have embraced the single-vendor solution and continue to be successful in a competitive marketplace."

Other large corporations have also chosen the single-vendor solution and are struggling in the marketplace. So, the choice between the single-vendor solution and the standards solutions does not seem to be the only factor for overall corporate success. With all the costs and burdens arising from the single-vendor solution, successful companies using the single-vendor solution will be more successful using a correctly defined and implemented standards solution.

Objection 7: "No one wants to pay for standards, so working on it is time wasted."

There are several corporations who are committed to standards in dimensional quality measurement. For example, the members of the Dimensional Standards Consortium (DMSC) (including Chrysler, Honeywell FM&T, Lockheed-Martin, and John Deere) and the members of the Automotive Industry Action Group (AIAG) (including Ford, Chrysler, GM, Caterpillar, Toyota, and Honda) have demonstrated commitment to manufacturing quality information standards. For example, DMSC members have been committed to standards solutions for over twenty years. However, participation and membership in these important groups is of highest priority if we are to realize the potentially large savings from interface standards.

In addition, ***the U.S. government has shown a sustained and long-term commitment to the standards solution, arguing that standards promote healthy commerce.*** NIST has been a focal point of resources and expertise dedicated to enabling interface standards for all industries, including manufacturing quality. However, NIST cannot justify resources towards standards unless industry shows its support for standards by joining with organizations like the DMSC and the AIAG and commits the supporting standards efforts with personnel and resources.

Who's working on quality information standards?

A wide variety of corporations worldwide are working on enabling measurement information standards – end users like Ford, Chrysler, GM, Honeywell FM&T, John Deere, Caterpillar, BMW, Audi, and Daimler – and quality measurement vendors like Mitutoyo, Hexagon, Xspect Solutions, Zeiss, Metrologic, Siemens PLM Software, Metris, Renishaw, Wenzel, Helmel, Applied Precision, Inc., Faro, Dassault, and others.

These corporations are joining with standards-generating bodies such as Automotive Industry Action Group (AIAG), MEPT, Dimensional Metrology Standards Consortium (DMSC), NIST, ISO, Society of Manufacturing

Engineers (SME), the Inspection Plus Plus (I++) group, and the International Association of CMM Manufacturers (IA.CMM), who are collectively working together to define and disseminate measurement information standards. They all argue that Manufacturing Quality Information Exchange Standards will save everyone – end users, tier suppliers, vendors, and customers – time and money.

Conclusion

With the proliferation of computers used to process, store, and transfer information, manufacturers are suffering increasing costs due to information incompatibilities. There are three "solutions" to the incompatibility problem: translation, single-vendor, and standards. The standards solution is the superior solution, due to the substantial savings of time and money that it offers over the long term, has no non-value-added costs, and offers increased freedom to end users and tier suppliers. The single-vendor solution is common, but is accompanied by a multitude of non-value-added costs that are substantial and persistent. The standards solution is superior only to the degree that 1) information standards development has sufficient end user funding and leadership, 2) the standard and its implementations are verifiably correct, complete, unambiguous, and timely, and 3) users require standards in purchasing requirements. Happily, these requirements are attainable. End user and tier supplier leadership and funding are very modest, particularly if the burden can be shared over a large group. The knowledge of how to develop a successful standard is known by standards experts.

Know-and-go:

- The information incompatibility problem in quality manufacturing is costly to everyone: vendors, suppliers, end users, and customers
- A mandated single-vendor solution is a popular solution to information incompatibilities, but is accompanied by a multitude of non-value-added costs that are substantial and persistent
- The standards solution is the best long term solution to information incompatibilities, since standards have no non-value-added costs and afford freedom for users and suppliers
- Standards development efforts need a modest amount of funding and leadership from tier suppliers and end users, which automatically guarantees participation from vendors and government experts
- Standards are the superior solution only to the degree that the standard and its implementations are verifiably correct, complete, unambiguous, and timely, but each of these requirements is attainable, but help from government standards experts can help ensure success