2015 Quality Information Framework (QIF) Standard Symposium Proceedings

Forward

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The Quality Information Framework (QIF, http://qifstandards.org) is a digital standard for end-to-end manufacturing quality information. It was developed and standardized by subject matter experts and computer scientists under the auspices of the Dimensional Metrology Standards Consortium (DMSC). The DMSC/QIF v2.1 has recently been approved by American National Standard Institute (ANSI) as an American National Standard. QIF supports digital thread concepts in engineering applications ranging from product design, manufacturing, to quality inspection and analysis. As such, the QIF is beneficial to some of the core approaches for next generation smart manufacturing, such as Model-Based Enterprise (MBE), Industry 4.0, and Internet of Things (IoT). Based on the Extensible Markup Language (XML) standard, QIF contains sets of software information models that are represented as XML schemas and that enable data integrity and process interoperability within manufacturing enterprises. Because of its XML foundation, the QIF standard can be easily integrated within model-based manufacturing environments. Being both human and computer readable helps reduce barriers for QIF's industrial adoption.

The specified QIF information models include:

- Model-Based Definition (MBD)
    - Solid and Tessellated Models
    - Semantic Product & Manufacturing Information (PMI)
    - Measurement Features
    - Product Characteristics
- Quality Planning
    - Measurement Scope
    - Bill of Characteristics (BoCs)
    - Measurement Resources & Rules
    - Inspection Plan
- Measurement Results
    - Piece Part Results
    - Statistical Analysis Results
    - Actuals with Nominals
- Enterprise Connectivity

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- Quality Persistent ID (QPId), for example, 619abed1-ff04-445a-319e-051861c4449b
- Providing quality Feedback to the Enterprise.

These information models cover an end-to-end cycle of quality inspection and analysis activities, depicted in Figure 1. The processes are often implemented by different vendors/parties yet readily integrate-able as a result of the respective conformance to the standard.

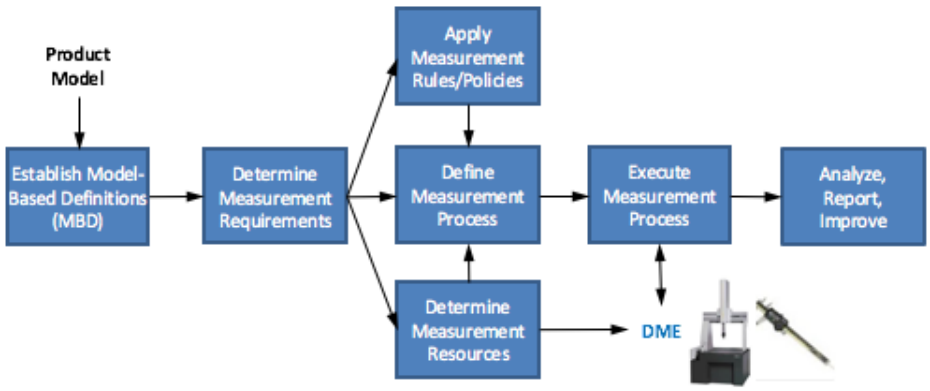

Figure 1: Quality Phase Activities

Note that this quality phase is a critical part of a high level model-based enterprise (MBE, described in a later section)[4], as depicted in Figure 2.

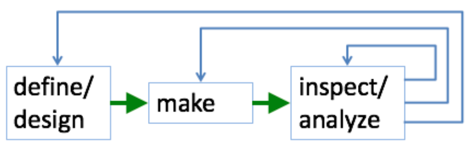

Figure 2: Manufacturing Process

The home website for QIF [http://qifstandards.org] contains detailed descriptions for this ANSI standard as well as allows for a free download of the standard's documentation and source code.

The inaugural QIF Symposium was held on October 6 through 7, 2015 at the University of Texas at Arlington Research Institute (UTARI), in conjunction with the week-long QIF Summit. A Call for Presentations, open to all practitioners, was issued in June 2015 and 14 submissions were accepted. This CMM Quarterly Special issue contains the Symposium presentation slides. The following introduction provides an overview.

[4] http://www.model-based-enterprise.org/index.html

Manufacturing Enterprise Perspective

It is essential to point out that quality operations are an integrated part of the manufacturing enterprise, which, as a whole, outputs products worth more than a trillion-dollars annually, covering a wide spectrum from automotive, aerospace, and medical to all other kinds of consumer goods. Industry has begun its next evolution, called Industry 4.0, which is anchored on digitized information, model-based approaches, and network technologies. Among the core concepts is MBE, which focuses on developing and utilizing digital models for manufacturing products and processes. This is a drastic upgrade from the traditional approach that relies on design drawings and machinists' skills.

In the presentation, entitled, "Quality Information Framework: The Key Enabler for the Digital Enterprise," C. Brown of Honeywell Federal Manufacturing & Technologies[5] describes the key features in QIF for enabling the next phase digital enterprise. He describes MBE as "A fully integrated and collaborative environment founded on 3D product definition detail and shared across the enterprise; … from concept to disposal." Information modeling and interoperability capabilities, such as provided by QIF, are critical within an MBE involving multiple manufacturing entities, including those original equipment manufacturers (OEMs) and suppliers.

QIF offers many key functions for an MBE, including assignment of persistent universal identifiers, called QPId's, wherever necessary, such as for feature items and characteristic items on products so that the respective quality statuses can be traced throughout the entire enterprise lifecycle. Another key function is the formation of part-centric product lifecycle management for trusted product models. The models are annotated with semantic PMI. This new approach, called model-based design, enables model validation within the full digital thread of the manufacturing enterprise. The trust and the certification are gained after fully passing the model validation and digital signature facilities embedded within QIF. These trusted models can be used to create functionally equivalent derivative models for further reuse. Thus, QIF helps form the basis for trusted design and the 3D technical data package (TDP) requirement that is specified in MIL-STD-31000.

The integrated MBE concept was also echoed in R. Admire's presentation, entitled "QIF Standard - How Can It Make Your Quality Organization More Affordable." He pointed out that QIF enables integrating native format-based designs, using computer-aided design (CAD) software, with open-standard-based inspection processes. He further pointed out that QIF enables integrating Standard for the Exchange of Product model data (STEP, ISO standard 10303) and model-based metrology. As a result, the streamlined process makes product quality not only less burdensome but also value-added to the enterprise.

Tools Supporting QIF

A main benefit that QIF MBD provides is a standardized information model for product/part definitions along with the associated PMI. Often and traditionally, this information is generated using CAD software and, as such, represented in the formats that are unique to the CAD systems. It is

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[5] Certain organization and product names are identified to facilitate communications. In no case do such identifications imply recommendations or endorsement by NIST, nor do they imply that the companies or products are necessarily the best available for the purpose.

advantageous to convert the formats to QIF such that the resulting QIF MBD would support all the downstream quality processes.

L. Fischer presented “Overview of Applications Supporting QIF.” His company, Capvidia, NA LLC., provides a collection of solutions to support QIF MBD, including converting CAD generated product definitions to the QIF format. Another Capvidia tool feature is to allow comparing derivative models, possibly from third parties, with the master model using the QIF format. Yet another tool feature is a software development kit (SDK) that can be used by third party tool vendors to provide their own QIF support. Capvidia’s QIF tools also allow comparing a QIF MBD with its pre-established digital product definition to enable certifying the MBD.

In the presentation entitled “QIF Measurement Resources Working Group Report,” H. Heysiattalab and E. Morse of University of North Carolina, Charlotte reported on the QIF library for quality measurement resources that they developed. Implementers could select the dimensional metrology equipment (DME) model from the library and generate the required inspection plans. Heysiattalab scoped the library and implemented it as QIFMeasurementResources.xsd. The library covered “measurement devices, tools, and auxiliary equipment available for measurement tasks.” Included in the information models for the resources were such attributes as “achievable accuracy, measurement speed, workpiece size, mass capacity, calibration history, sensors, fixtures, and work volumes.” Heysiattalab further presented a hierarchy that encompassed both the implemented resources and those that would be developed in the future – particularly those additional resources that were specified in ASME B89 and the ISO 10360 standards series.

G. Tatarliev of Kotem Ltd. described the company’s software, SmartProfile’s, QIF support. Prior to adopting QIF, SmartProfile’s normal process was to import the CAD model for the part to be analyzed, apply the associated tolerances, import the measurement data, and conduct analysis before generating the report. With QIF MBD, the tolerance specifications and the measurement data are both in the standard format and ready for SmartProfile™’s processing. The improved process results in significant cost reduction in the quality analysis.

D. Campbell presented “Metrosage and QIF.” He described the company’s tool, Pundit CMM, that computed measurement uncertainty for a measurand from the inputs of associated CAD models, Geometric Dimensioning and Tolerancing (GD&T) information, sampling patterns for the measurement, manufacturing signatures, and the measurement resources (see Figure 3). The resulting uncertainties indicated the geometric quality of the manufactured part. Pundit CMM™ also optimized QIF inspection plans.

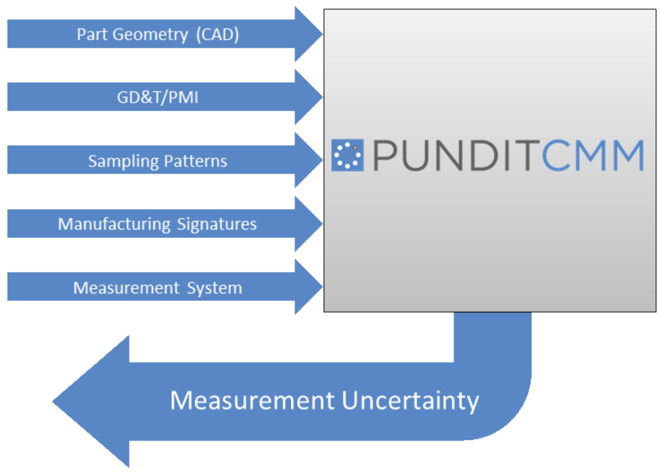

Figure 3: Pundit CMM™

A. Soma of the Japan Electronics Information Technology Industries Association (JEITA) presented "Overview of new GGT - Introduction of General Geometrical Tolerancing (GGT)." The focus was introducing a new method for describing the GGT versus the ISO standards – specifically, the proposed GGT aimed at improving upon the limited applicability of ISO 2768. The general concept of GGT, as described in ISO 2102, is to take into consideration "the respective customary workshop accuracy." Typically, specifying tolerances larger than the accuracies that the workshop can achieve provides no manufacturing advantage. In such a situation, individual tolerances "could be skipped in the design" and an overall tolerance was used instead.

H. Huang of the National Institute of Standards and Technology presented system wide research issues regarding QIF, such as how QIF could play a key role between a high level manufacturing operation, where the ISA95 standard is applicable, and the low level machine control concerns. Also discussed was the issue of manufacturing error budgeting and analysis as well as the associated product acceptance/rejection rules issues. A brief description on how QIF could fit into the cyber physical system (CPS) construct was provided. He also summarized the benefits that QIF could provide, from engineering, operational, and management perspectives. He pointed the audience to http://www.nist.gov/el/msid/syseng/smopc.cfm for additional information.

G. Wetsig of Northrop Grumman presented "First Article Inspection Report (FAIR) & Technical Data Packages, Digital Thread, Manufacturing Readiness Level's (MRL), and Sustainment." He described some of the Government perspectives on quality when acquiring major engineering systems. He also suggested the QIF working group seek opportunities to influence ISO 9000 to accommodate the new digital landscape. He explained that the first article inspection (FAI) results could serve as a reference point for process and dimensional yields. He also pointed out that production representative data analysis could begin when the manufacturing readiness levels (MRL) reaches the value of six.

QIF Applications/Adoption

R. Fruit of Mitutoyo America Corporation presented "QIF: A Real World Implementation Case Study using Mitutoyo MeasurLink™." The company's QIF supporting MeasurLink™ software was a part of the quality solution that was provided for a client. This client planned to use QIF as a part of "a suite of quality apps and services that have the features we need while letting them (the quality apps and services) share data easily." In this application, QIFPlans will be generated and executed and QIFResults and QIFStatistics will be generated, analyzed, and stored as a part of the client company's enterprise resource planning (ERP) archive. Some of the implementation experiences with QIF were also presented along with several proposals on improving the standard.

R. Stone of Origin International presented how his company's products support QIF. CheckMate™ can consume QIF MBD and QIF Plans to produce CMM programs for part measurement and can produce QIF Plans and QIF Results. CMEngine™ can produce QIF results, standardized for the consumption of various third party software. These are helpful tools for open QIF implementation. Stone also proposed for the working group to produce QIF implementation guides to help adoption of QIF.

T. Ventura of Innovalia presented "Intelligent Manufacturing and QIF: From a Conceptual Model to Practical Experiences." He described a scenario when the re-emerging manufacturing, under Industry 4.0, has the characteristics of being digital, internet-based, intelligent, and virtual. Within metrology, one main reason for using QIF is that quality operations need to collect, organize, and use digital manufacturing data constantly. With the standardized information models, QIF plays a crucial role in supporting Industry 4.0 and IoT. He also described another scenario when human intelligence should be fully integrated with modern manufacturing systems—such systems were CPS in nature. He covered the entire spectrum of human intelligence issues, from intention, sensing, through semantic knowledge and decision making. He also described that simulation played an important role within the CPS construct.

J. Wallace of the Manufacturing Technology Center (MTC), UK, presented "QIF and the British Manufacturing Supply Chain." MTC's objective was to create an "intelligent cloud" for automating metrology processes, often distributed among multiple tiers of suppliers, original equipment manufacturers (OEMs), and the primary manufacturers. Therefore, it is very beneficial to standardize the measurement information formats across the supply chain. She presented that the current practices are mostly manual, prone to many types of human errors, as well as suffering from inadequate PMI support. Using QIF to facilitate computer-aided inspection could significantly improve the quality operations and reduce costs.

The second QIF Symposium is planned to be held in October, 2017. We encourage you to submit write-ups describing your perspectives on manufacturing quality. Please either contact the guest editors for this Special Edition or refer to http://www.qifstandards.org for the announcement in early 2017.

The Symposium provided perspectives of a set of the QIF tools that were either already or soon to be available in the market as well as how QIF was being applied. Also presented was a perspective on how QIF continues to serve as an enabler for adding significant value to a digital model-based enterprise. Readers are strongly encouraged to investigate the benefits of QIF, convey your findings to respective quality solutions providers, metrology departments, or MBE strategy teams, and encourage these entities to adopt QIF. The ANSI version of the DMSC/QIF is currently available at no cost.