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Interoperability: linking design and tolerancing with metrology

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Abstract

On October 30, 2014 the American National Standards Institute (ANSI) approved QIF v 2.0 (Quality Information Framework, version 2.0) as an American National Standard. Subsequently in early 2016 QIF version 2.1 was approved. This paper describes how the QIF standard models the information necessary for quality workflow across the full metrology enterprise. After a brief description of the XML 'language' used in the standard, the paper reports on how the standard enables information exchange among four major activities in the metrology enterprise (product definition; measurement planning; measurement execution; and the analysis and reporting of the quality data).

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Keywords: Standards; Metrology Data; Interoperability

1. Introduction

Metrology has – at times – been placed in the role of quality checking, the final step of conformance testing before a product is deemed acceptable. The more advanced manufacturer of components realizes that there is more value in metrology than a simple final-acceptance check. Using metrology information to improve the manufacturing process by controlling and reducing product variability has become an integral part of modern, high-quality manufacturing. The management of variability is more easily performed in organizations that are integrated vertically because different parts of the process 'belong' to the same company. In a flatter, more distributed, manufacturing environment this task is much harder, as each participant (company, division, etc.) may optimize their part of the process to the detriment of the complete process's quality. Standardization is recognized as a means to allow interoperability across a variety of platforms in almost countless contexts, from standardized reporting of gasoline octane content based on underlying test methods to the height of work surfaces, including office desks and commercial kitchen counters. The specific focus of this paper is Product and Manufacturing Information (PMI) for discrete products.

The goal of the Quality Information Framework (QIF) [1,2] is to support the transfer of information and data related to metrology through the entire product process, from design to manufacture to the archival and analysis of data related to the products. This paper will provide a high-level overview of the current QIF structure and the various components of this structure. We will then focus on one particular area (i.e., metrology resources) in more detail, both to examine the thinking behind the development of this area and to reveal how we envision end users realizing the benefits of the QIF. We will conclude with some specific attributes of the metrology resources structure that relate to large scale and portable metrology systems.

Acronyms

QIF	Quality Information Framework
XML	Extensible Markup Language
PMI	Product and Manufacturing Information

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2. The Quality Information Framework (QIF)

The QIF captures the natural structure of information flow related to part geometry: from the initial description of the geometry and the supplemental information that is provided by the designer all the way to the statistical analysis of inspection results for multiple workpieces. At each step along the way, the necessary information is captured in a standard format, allowing greater flexibility in choosing the tools used in the next process step. The standard format is defined using Extensible Markup Language (XML) and demonstrated using a variety of tools that support the QIF standard [3].

2.1. XML schemas and files

XML is readable by both humans and computers. The same file that is used for modeling a particular situation can also be examined by a person looking for particular information. This is similar to the use of HTML for web pages. The two main types of files that we will consider are XML Schema Definitions, herein schemas, and XML files. The QIF consists of schemas, which define templates for the type of information needed in each step. When QIF is used, an XML file is generated, which could be evaluated to see if the file conforms to the schema. The file fragments below show a simple example of the relationship between the schema definition and an instance of a particular use of the schema.

Table 1. XML schema and XML file example.

```
<xs: element name="Contact">
  <xs: ComplexType>
     <xs: sequence>
       <xs: element name="name" type="xs:string"/>
       <xs: element name="FamilyName" type="xs:string"/>
       <xs: element name="Address" type="xs:string"/>
     </xs: sequence>
  </xs: ComplexType>
</xs: element>
```

Fragment of an XML schema definition

```
<Contact>
    <name>Ed</name>
    <FamilyName>Morse</FamilyName>
    <Address>UNC Charlotte</Address>
</Contact>
```

Resulting XML file instance

In Table 1, the schema defines what information is needed (i.e., it's a template), and the user puts the appropriate information in an instance XML file. Many XML files could be created that conform to the schema template.

2.2. The QIF schemas

The QIF schemas are used at the conclusion of each step in the product-quality process so that the data passed to the next step has a standard format. For example, when the design of the part geometry and tolerances is concluded, it may be transferred to metrology in a native format, or in another standard format such as ISO 10303-202 Managed Model-based 3D Design, known as STEP AP242 [4]. It may also be exported according to the QIF MBD (model-based definition) schema. This ensures automated processes that determine measurement requirements, based on the part geometry and tolerances, have access to the information needed to complete this task. Note that as in the above example, the schema doesn't describe the geometry – simply how the geometry is captured in the file. The other QIF application schemas used are QIF Resources, QIF Rules, QIF Plans, QIF Results, and QIF Statistics. The execution of measurement programs within the QIF uses DMIS version 5.2 [5]. These application schemas rely on common elements that are captured in the QIF libraries, as shown in Fig. 1.

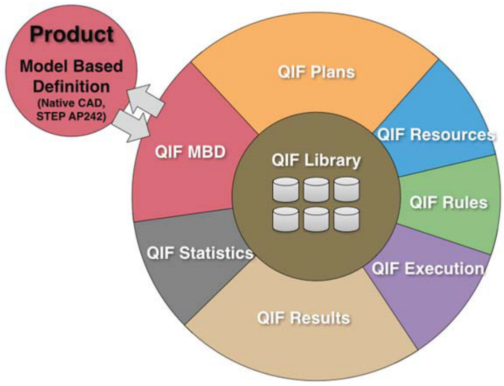

Fig. 1. A representation of the QIF schemas and the supporting libraries

The role of these data models is apparent when we think about the quality process: given the part geometry and tolerances, what is needed to develop a measurement plan? The identification of the part attributes that must be measured is determined by the quality requirements and by the manufacturing processes used. This information is captured in the "whats" portion of the QIF Plans schema. Once it is known what must be inspected, the information about available metrology resources (QIF Resources) and rules for applying these resources (QIF Rules) must be applied to complete the "hows" portion of the QIF Plans. Now the measurement plan is complete, this is implemented using DMIS and the results are captured in accordance with the QIF Results schema. Finally, post processing can be accomplished according to the QIF Statistics schema. As a reminder to the reader, each of these schemas simply provides a template for moving information. Fig. 2 shows the alignment of the various schema definitions to the different tasks in the metrology lifecycle.

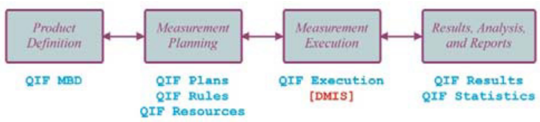

Fig. 2. The parts of QIF related to the overall metrology workflow