The Dimensional Markup Language Specification
for Inspection Results Data

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Abstract:
The Dimensional Markup Language (DML) specification defines a data model and extensible markup language (XML) encoding rules for dimensional inspection results for discrete parts. To support manufacturing quality assurance processes, DML results files are conveyed, typically from coordinate measuring machines, to analysis, reporting, and database applications. The development of DML is now a joint project between Automotive Industry Action Group (AIAG) and Dimensional Metrology Standards Consortium (DMSC), with the next version of the schema and specification document expected to be ready for American National Standards Institute (ANSI) balloting in the fourth quarter of 2009. The goal of DML is to enable systems from different vendors to exchange inspection data seamlessly, without need for translation of data from proprietary or ad hoc formats. The benefits of products that support this standard data format include: lower overhead effort for software vendors (reader and writer products support one data format), potentially lower integration cost to users, elimination of restrictions on products that can be purchased due to lack of support for proprietary data formats, effortless integration of SPC products.

The Dimensional Markup Language (DML) specification defines a data model and Extensible Markup Language (XML) encoding rules for dimensional measurement results for discrete parts. To support manufacturing quality assurance processes, DML results files are conveyed, typically from coordinate measuring machines (CMMs), to analysis, reporting, and database applications. Coordinate Measuring Machine (CMM) execution software writes DML–compliant information, and measurement reporting and analysis software reads DML-compliant information.

The development of DML is a joint project between the Automotive Industry Action Group (AIAG) and Dimensional Measurement Standards Consortium (DMSC), with the next version of the schema and specification document expected to be ready for ANSI balloting in the fourth quarter of 2009. Even though DML was originated by the

Automotive Industry Action Group (AIAG), this specification applies to a wide range of manufacturing industries and is not limited to automotive applications.

DML enables software from different vendors to exchange inspection data seamlessly, without the need to translate data from proprietary or ad hoc formats. DML supports a standards-based alternative to common practices of either buying software products that translate to or from proprietary formats (when they are available), or buying products from a single vendor. The cost of translation includes users paying for translation functionality and risking degradation of data, as well as overhead to developers of supporting non-value-added features. The single vendor approach limits user choices, and in the case of tiered suppliers, may force them to purchase additional software tools that are mandated by their original equipment manufacturer for interoperability.

The benefits of products that support the standard DML format include: lower integration cost to users, lower overhead effort for software vendors (reader and writer products support one data format), elimination of restrictions on products that can be purchased due to lack of support for proprietary data formats, and effortless integration of Statistical Process Control (SPC) products that support DML.

There are two groups driving DML development: users and vendors. Both groups will benefit from DML. Users benefit because DML-compliant software lowers software license costs, reduces information quality losses, and provides greater freedom of choice. Vendors benefit because widespread use of DML compliant software by a critical mass of users saves vendors large non-value-added translation costs.

DML defines substitute geometric features, such as cylinder radius, which are not directly measured, as well as features which are directly measured, such as points. However, DML also defines all the raw measured values, so that substitute geometric features and elements can be re-computed by the consumer of DML information, perhaps in order to use different algorithms to re-compute the substitute geometric elements.

Support for DML development comes from the members of the standards committee and working group, comprising companies that buy and use CMMs and SPC software, and companies that develop and sell these products. When asked why they are expending resources on DML, one vendor responded:

- "The interoperability of DML provides a solid foundation to promote sharing and consumption of measurement data. DML to us means time and cost savings and happy customers because it allows us to quicken implementation of new quality systems while providing flexibility to integrate DML output with existing measurement dependent systems.” - Scott Hoffman, President, Senior Applications Engineer, Validation Technologies Inc.

The technical content of DML supports

- Information used to specify nominal, measured and constructed features and feature tolerances, and results of post-part-measuring analysis.
- Information related to planning and programming includes naming and linkage conventions for relating features in Computer Aided Design (CAD) models to actual part features and to the feature-analysis results.
- Common coordinate system definitions for reporting results, especially for cases when parts are inspected using multiple dimensional measurement equipment (DME).
- Traceability information (for post-inspection analysis), e.g., which machine was used, what software application produced the DML data, name of the CAD file that provided feature information, who was the operator, and date and time of the inspection.

Some specifics of the DML format are:

- Inspection results are limited to a single part inspection per file.
- Definitions support American Society of Mechanical Engineers (ASME) geometric Dimensioning and Tolerancing (GD&T)[1], ISO 10303-219:2007 (Standard for the Exchange of Product Data (STEP) Application Protocol 219[2]) and Dimensional Measuring Interface Standard (DMIS) 5.1[3] standards for features and tolerances.
- Results are included from traditional touch trigger data sources and scanning probes.
- Measurement results can include raw data measurements, parameters of the measuring device such as probe tip diameters, and calculated results such as features, tolerances, and transforms.

The DML specification does not now include:

- Inspection program statements
- Descriptions of machine capability
- Product Data Management (PDM) level information
- Multi-part results or analyses, such as Statistical Process Control (SPC)
- Non-dimensional quality measurements, such as temperature and pressure

Non-dimensional inspection information relevant to the discrete parts world was considered for inclusion in DML, but will likely not be incorporated in this version. Examples of data being considered for future editions include attributes of measurement method including orientation and measurement method, and non-dimensional measured characteristic information such as color, weight, and binary (yes/no) attributes.

Figure 1 shows the information flow architecture of an example standards-based discrete parts inspection system. Applicable standards for files are indicated in square brackets, e.g. [DMIS]. A manufacturing engineer uses the CMM Programming application to produce a CMM Program that is executed by a CMM Execution application (CMM programming and execution applications are usually the same product). Inspection of one part produces a DML file for that part. DML files are conveyed to other quality processes, most often for SPC analysis. DML content is harmonized to support integrated processing of all of these files. That is, DML content must support inspection command statements in DMIS programs, as well as the analysis needs of the downstream SPC processes.

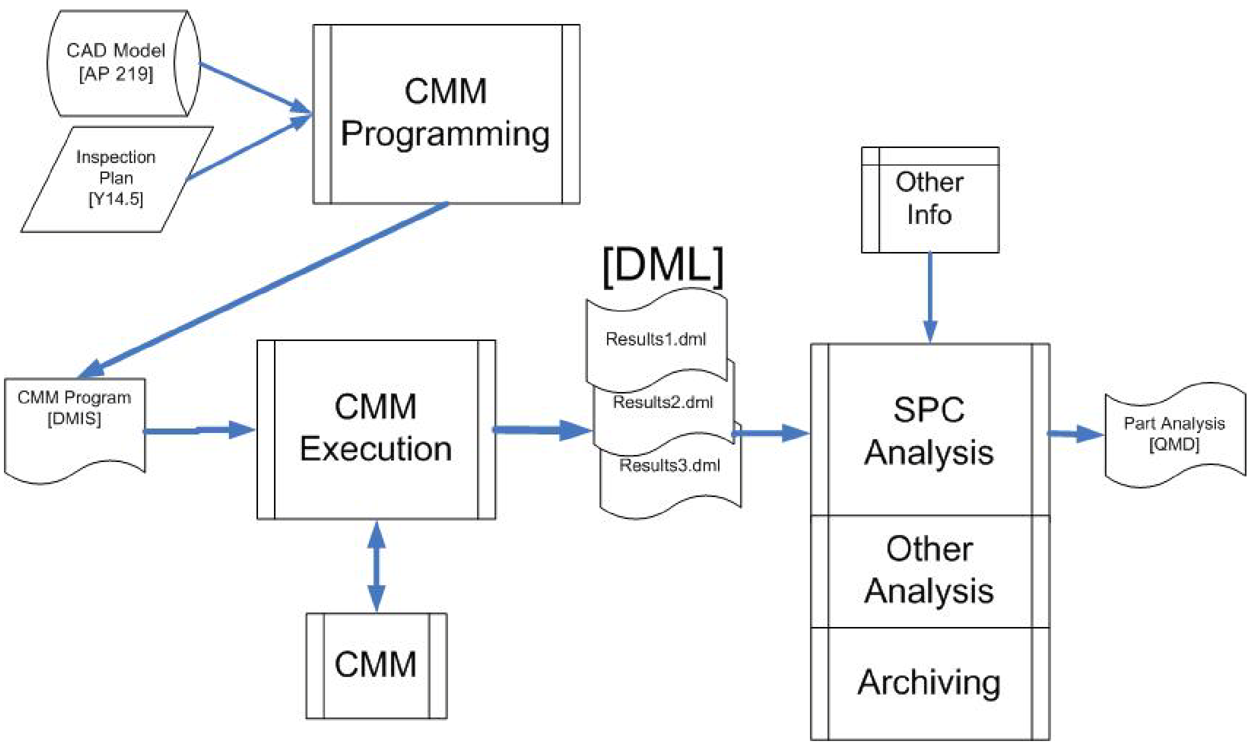

Figure 1. Information flow for discrete part dimensional inspection, including part design, inspection planning, inspection programming, and transfer of individual part results to analysis processes. The content of DML is aligned with the other specifications for inspection process data (AP 219, Y14.5, DMIS 5.1, Quality Management Data (QMD)[4]).

For questions, contact the DML committee chairman, Bill Rippey of NIST, william.rippey@nist.gov, 301.975.3417.

Bibliography

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[3] "Dimensional Measuring Interface Standard (DMIS)," Dimensional Metrology Standards Consortium (DMSC Inc.), ANSI/DMIS 105.1-2007, Part 1, Nov.2007.

[4] "QMD Quality Measurement Data: A Guideline for Specification and Implementation, version 1.0," Automotive Industry Action Group (AIAG), D-25, Apr.2007.