

AIAG DEMONSTRATES METROLOGY INTEROPERABILITY: TO SAVE YOU TIME AND MONEY

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ABSTRACT

The Automotive Industry Action Group (AIAG) is working on the challenges of interconnecting components of automated dimensional metrology systems. Our presentation explains how products that support interoperability standards for components of metrology systems can save you time and money. The key is that components from different vendors, chosen by users, can be connected easily and effectively to build dimensional metrology systems. These capabilities have been demonstrated in trade show booths at IMTS 2004, Quality Expo 2005, and Control 2005. Applicable components include CAD systems, CMM programming and execution packages, CMMs, and analysis programs for part inspection and SPC. The applicable standards are: STEP, for conveying CAD data with GD&T, DMIS for inspection programs, I++DME for linking CMM execution software with CMMs, and DML for reporting CMM inspection results.

AIAG'S METROLOGY INTEROPERABILITY PROJECT TEAM

The Automotive Industry Action Group established the Metrology Interoperability Project Team (AIAG-MIPT), with the following mission:

“The Metrology Interoperability Project Team goal is to reduce product development cycle time and manufacturing costs by achieving interoperability of the software and hardware components used in automated metrology. This team's main goal is to provide a single voice of the user in specifying interoperability requirements.

Activities within the scope of this group include:

- Identifying gaps within the current standards
- Performing in-depth evaluation of current and developing standards for particular interfaces, to determine which to support
- Identifying and assisting in the harmonization of competing and overlapping standards
- Developing and performing conformance and interoperability tests
- Developing consensus user requirements to provide as input to standards developing organizations.”

Standards Landscape

Figure 1 shows four areas of standards usage that AIAG hopes to impact: STEP for conveying Computer Aided Design (CAD) data with geometric dimensioning and tolerancing (GD&T) data, DMIS for inspection programs, I++DME for linking CMM programming and execution software with coordinate measuring machines (CMMs), and Dimensional Markup Language (DML) for reporting CMM inspection results. The cooperative demonstrations developed by AIAG, NIST, and product vendors, have involved two of the four areas, namely I++DME and DML.

The Standard for the Exchange of Product Data (STEP) is an ISO effort to define computer-interpretable data that describes products, and the ways to exchange the data [7]. Dimensional Measuring Interface Standard (DMIS) describes a neutral format for inspection programs and inspection results [4]. I++DME describes a communications interface between measuring devices, typically CMMs, and execution control software. DML “is an XML format for dimensional information that completely captures results as well as the data used to calculate those results.” [3]

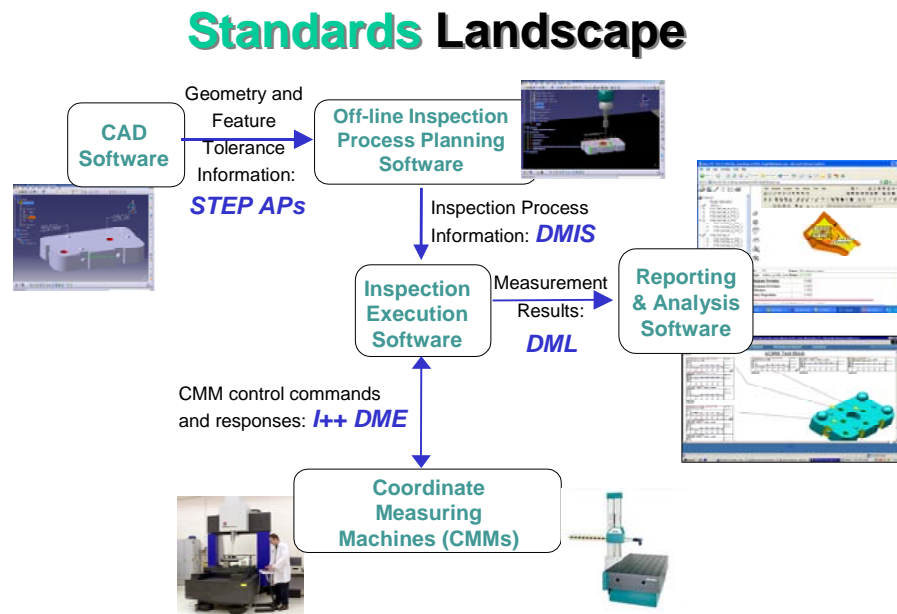


Figure 1. The AIAG is focusing on these areas of standard interfaces.

INTEROPERABILITY OF COMPONENTS AND DATA

Interoperability of inspection components means that for any component of a metrology system, a component can be swapped out and replaced by a comparable component from a different vendor, without sacrificing functionality. Interoperability through custom engineering of interfaces can be very effective, and several products are very versatile. However, the cost to developers is high, and users still often cannot combine components to suit their needs. AIAG is pursuing interoperability through standard interfaces, to save users and vendors alike time and money. The advantage of interoperability is important to a

company that supports over a dozen different CMM programming systems, as well as the shop that has only one CMM and needs to buy another.

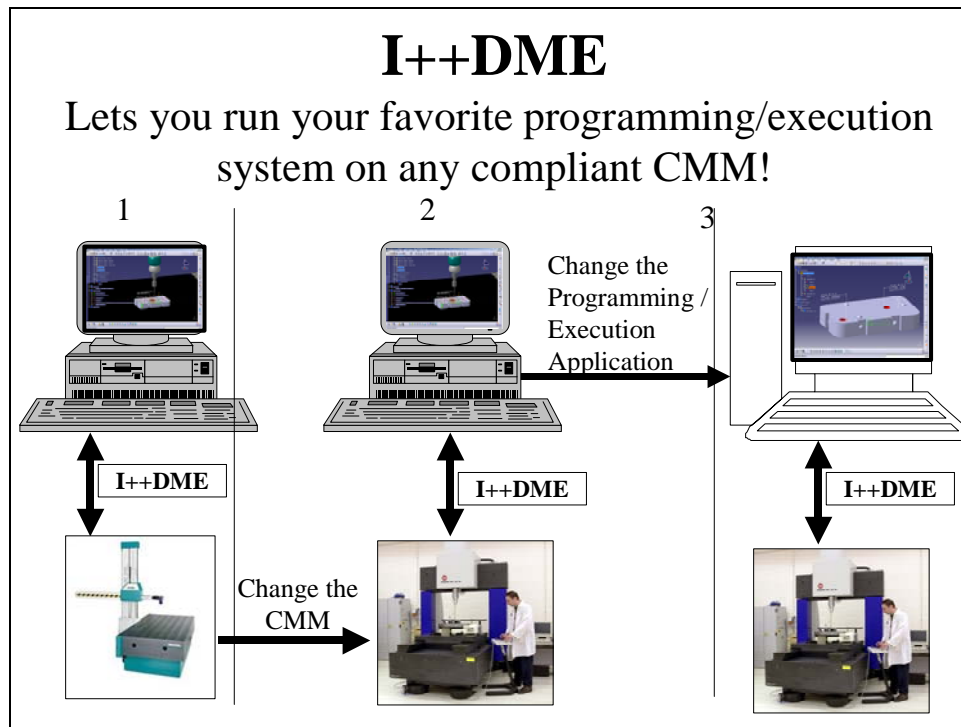


Figure 2. The I++DME interface gives users choices of software and CMM components. It links CMM execution applications with the CMM motion and probe system.

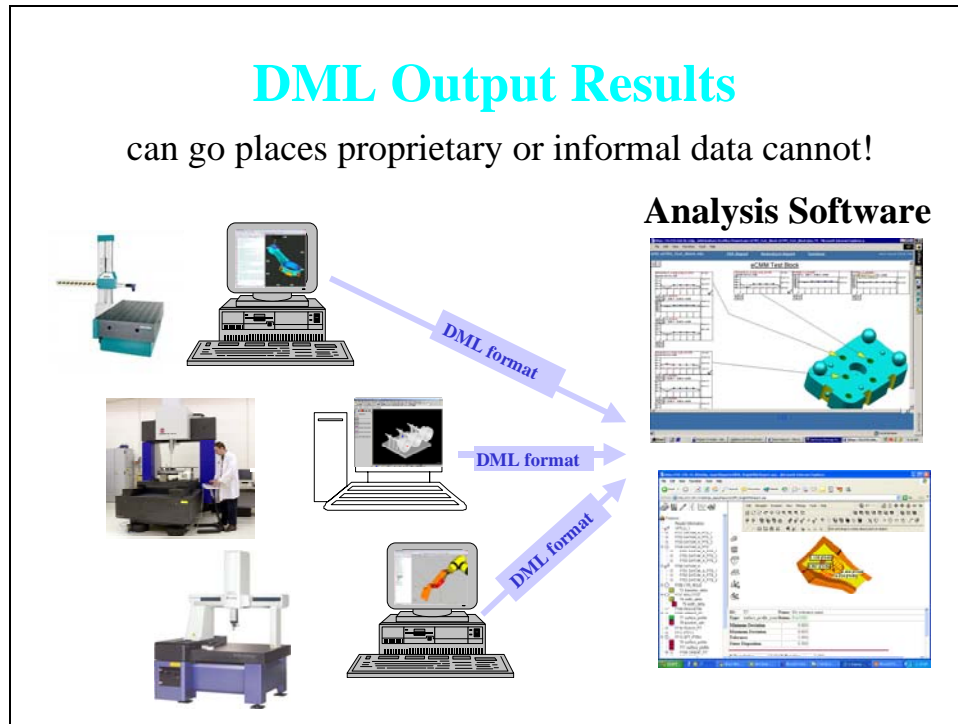


Figure 3. The Dimensional Markup Language (DML) specifies the format for inspection result files, using XML technology.

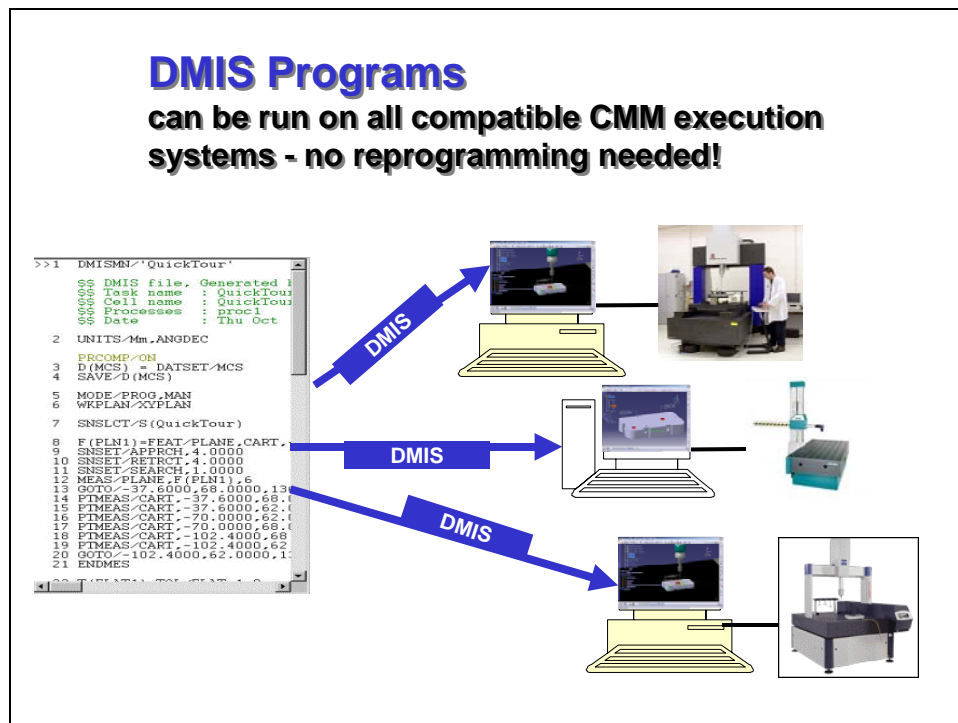


Figure 4. DMIS programs can be moved to different CMMs, without reprogramming.

The Costs of Incompatible Components

Plants with two or more CMMs from different vendors can face the following challenges to efficient use of their resources:

- training costs are high because the plant maintains different CMM programming/execution systems
- moving a part inspection from one CMM to another, requires regeneration of CMM programs in a different language
- conveying inspection results data from CMMs to analysis software packages is difficult
- plant management cannot purchase best-in-class components because of commitments to proprietary products

In 1999 the Research Triangle Institute did an assessment of overall economic impact of lack of interoperability of product data in the automotive industry. The report put the total cost to companies in the supply chain, conservatively, at one billion dollars per year [8]. The issues in metrology being addressed by AIAG are a subset of this total.

Benefits of Products that Support Standard Interfaces

AIAG is promoting use of products that have control and information interfaces that conform to open standards. The advantage gained is that products from different vendors can be interconnected, without custom engineering of interfaces, or without conversion of data formats.

Issues of interoperability (or lack of it) occur in manufacturing facilities when users want to balance inspection operations among several machines by moving the inspection of a part from one CMM to another, when they want to keep inspections going when a CMM fails, or when they need to convey inspection programs developed at one plant to the equipment of another plant. The costs of these operations, using products from different vendors, can be time and money to train programmers and operators in multiple systems, time and money to rewrite programs, and production schedule time lost when inspections are delayed. The I++DME and DML open standard interfaces offer CMM users the chance to purchase components that are compatible with existing components, when obtaining new systems, or when retrofitting older CMMs with new controllers. Figure 2 shows how the I++DME interface supports building an inspection system, over time, with a user's choice of software and CMM. Figure 3 shows how inspection results encoded in DML, by a variety of products, can be conveyed to a variety of analysis applications. The impact of the open standards is that users of metrology systems have more choices of components they buy and use.

The benefits, to users, of products that support standard interfaces are:

- ease of interconnecting products that support standards
- reduction of training and maintenance costs
- flexibility in choice of components by users, allowing them to buy the best product, or the least expensive product, or the one their personnel are already familiar with
- increased competition among vendors, reducing your costs.

The vendors of CMMs and software applications that have participated in the AIAG demos are supporting standard interfaces and the AIAG efforts to publicize them. Many are members of the I++DME and DML specification writing teams. They are developing interfaces on their existing products and testing them against utilities developed by NIST, and against products of other vendors. The potential benefits that brought three competing CMM vendors and seven competing software vendors together, in the AIAG booth at the International Manufacturing Technology Show 2004 include:

- a CMM vendor may be able to sell a machine to a plant that does not currently have any of their machines, because the I++DME interface lets the plant use their current software and incorporate a new CMM
- a software vendor can introduce programming and execution software (again using the I++DME interface) to a plant without requiring it to change brands of CMMs.
- a CMM, or execution software, that has the ability to export inspection results in the standard DML format, has features that are attractive to users that need ease of information flow.

STANDARDS DEVELOPMENT AND THE ROLE OF TESTING

Testing Improves Specifications and Ensures Product Interoperability

A specification for an interface or for a data format requires rigor and clarity so that software developers from different companies have the best chance of interpreting the intention the same way. Achieving interoperability requires testing by vendors, before their products get to users.

To support the delivery of timely, unambiguous, robust standards, NIST is helping to test products while their new interfaces are being developed, and while the standards are still being revised. NIST has developed test utilities for testing I++DME and DML interfaces, and is keeping them current with specification revisions. These utilities are offered to the public (http://www.isd.mel.nist.gov/projects/metrology_interoperability/). The utilities include conformance tests that are used to determine how well implementations conform to the intent of the specification. Performing conformance testing on a product is essential, before introducing the complexity of connecting one product to another and assessing interoperability.

NIST's Role

NIST's activities have included: generating conformance test utilities; performing conformance and interoperability tests; reviewing and critiquing standards; maintaining a testbed with support from industry partners; facilitating interaction between participants and generating feedback; planning and conducting public demonstrations. NIST has also filled a leadership role in organizing efforts and facilitating communications (we moderated over 50 meetings in 2004).

Trade Show Demonstrations

AIAG, NIST, and several inspection system vendors have conducted intensive efforts in 2004 and 2005, to conduct public demonstrations of metrology systems performing typical inspections using components from different vendors. The components were integrated using the I++DME and DML standard interfaces, shown in Figure 1. The demonstrations publicize the standards, and show that standard interfaces can support required inspection capabilities and component interchangeability. Further, the preparations before the show have provided valuable lessons-learned to both specification developers and product vendors, on the interpretation of specifications by software implementers, and on the technical validity of the specifications.

The impact of public interoperability demonstrations goes beyond increasing the public awareness of the existence, nature, and quality of the interface standards. The exposure in the trade shows energize the community to begin, or step up, their work on implementations and complete them by the demo deadline. The testing among products of different vendors exposes ambiguities in the specification, and highlights sections that are interpreted differently by software developers, and thereby improve the specification. Further, managing the coordination of the parties involved shows the need for the role of someone like NIST, to act as a neutral party, and to supply test utilities, test procedures, test cases, and test metrics.

IMTS, September 2004

AIAG's first demonstration of interface standards was at IMTS, September 2004, with the help of NIST and several vendors of CMMs and inspection execution software. The standards employed were I++DME and DML. Three CMM vendors installed their machines in the booth, and six vendors of software loaned their applications to NIST for installation on laptop computers. NIST demonstrated that all six software applications could operate each of the three CMMs, using the I++DME interface. Two of the applications also exported inspection results in DML format to two database servers, each from a different company.



The CMMs and software applications of the AIAG booth at IMTS 2004

Quality Expo, April 2005

At the time of this publication, March 2005, AIAG and NIST, and several product vendors were planning to repeat the IMTS demo at Quality Expo, Rosemount, IL, April 19-21, 2005. Plans are to show more capabilities of the I++DME and DML interfaces, including tool changing and use of scanning probing.

Control, April 2005

The International Association of CMM Manufacturers (**ia.cmm**) supports the development of the I++DME specification. **ia.cmm** sponsored a booth at the Control 2005 show, April 26-29, in Sinnsheim Germany. The software applications hosted on NIST computers from IMTS and Quality Expo were used to connect to CMMs supplied by **ia.cmm** members. At press time NIST expected six or seven software applications to be connected to four different CMMs, using the I++DME interface.

Trip reports describing the activities at all three trade shows are available on the NIST web site, http://www.isd.mel.nist.gov/projects/metrology_interoperability/index.htm. Click on the link on the left side for “IMTS 2004 Demo Trip Report”, “Quality Expo 2005 Demo Trip Report”, and “Control 2005 Demo Trip Report”.

FUTURE EFFORTS

Two areas in the AIAG standards landscape, I++DME and DML, have received moderate attention and need more activities for robust product interoperability. Activities toward this goal include:

- Convey the I++DME specification to ISO
- Write a formal DML specification document

- Upgrade NIST's current I++DME and DML test suites for greater coverage of the specifications as they grow in scope.

AIAG and NIST would like to begin efforts to help promote the DMIS and STEP AP interfaces. Specifically, goals would be:

- Perform analysis to harmonize I++DME with DMIS
- Help the DMIS National Standards Committee (DNSC) in defining DMIS conformance classes
- Help DNSC in developing DMIS conformance test suites.
- Generate a bootstrap demo using STEP to convey part feature data, with GD&T data, from design CAD systems to inspection programming systems.

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