

Software Frameworks for Integrated Measurement Processes

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1. Introduction

With the continuous diffusion of CAD technology into industry and increasing requirements for higher efficiency, integrated measurement processes (IMP) are becoming more and more important. High performance IMP implies reduced measurement uncertainty, dynamically configured plans for different parts, and shared measurement data among different application departments in an enterprise. A new software framework is needed to meet these requirements.

Currently, there is no complete system architecture or transport protocol defined to integrate CAD, CAM and CMM applications although several partial solutions are available from commercial vendors such as Brown & Sharpe, IMS, and Technomatix.

In this paper, we describe a project that is underway to provide software frameworks for integrating the measurement process in the automotive and aerospace industries. Several technologies that have tight relationships with this project are examined. Based on these technologies, some important aspects of the project are described. Finally, the effect of IMP on measurement uncertainty is discussed.

2. Existing Technologies to IMP

The design philosophy behind the IMP is to leverage the best features of existing technologies and standards, while at the same time, preserving the principles and semantics of measurement processes.

2.1 *Web and XML*

The use of the Internet, the World Wide Web and XML is a de facto requirement in new system integration projects that address application interoperability and data exchange. The reason for this is that the ubiquity and acceptance of the Internet and World Wide Web provide the furthest reaching and lowest cost integration platform in the world.

XML is a good approach for deploying structured information on the web because it marries the presentation-free content management view of SGML to the de facto language syntax of the web established by HTML. XML data may exist either independently or using a separate DTD file to define its data structure. The presentation of XML data is accomplished either directly or by using an HTML file that has been transformed by an XSL file.

2.2 *STEP Technologies*

STEP (STandard for the Exchange of Product model data) is a set of standards (ISO 10303) for a computer-interpretable representation and exchange of product data to provide a mechanism capable of describing product data through out its life cycle while independent of any specific system. STEP consists of different parts including a description method, integrated resources, and application protocols, as well as implementation methods and abstract test suites. It can be expected that STEP will become the industrial standard for product data exchange. Seeing this

trend, many CAD/CAM systems now provide interfaces to STEP data models in order to keeping their systems in the market.

STEP defines a set of Application Protocols (AP) to represent a domain in different industrial fields. Each AP includes an application activity model (AAM), an application reference model (ARM) and an application integrated model (AIM). In practice, industrial applications may use only a subset of an AP or may combine aspects of more than one AP to create a given system. A new AP (Ap219) currently under development in the STEP group is quite useful for IMP.

AP219 will specify information requirements to manage dimensional inspection of solid parts (or assemblies) that includes administering, planning, and executing dimensional inspection as well as analyzing and archiving the results. Ap219 is a comprehensive application protocol, which may use information from other application protocols, such as AP203, AP214, AP224 and other resources.

The AP AIM is what a user employs to define product data. It is written by using the EXPRESS or EXPRESS-G languages, which provide an object-oriented information modeling language and mechanisms for specialization and generalization of entities that represents product data. A typical geometrical model represented with EXPRESS is hierarchical.

2.3 DMIS

DMIS (Dimensional Measurement Interface Standard) is a standard (ANSI/CAM-I 101-1995) created by the Consortium for Advanced Manufacturing International to enable coordinate measuring machines (CMMs) to communicate seamlessly with each other. Traditionally, each CMM manufacturer developed its own programming language and embedded it within its measuring-application software. As a result, most installed CMMs were unable to execute each other's inspection part programs. Fortunately, CMM software vendors have reacted to this situation and begun to provide interfaces for two-way communication via DMIS.

3. Divisions of IMP

IMP will need to consider the integration of many applications. Normally, incremental implementations are most successful for this kind of system integration project. In this type of approach, integration designs of limited scope are defined and implemented using a spiral development model. Each incremental step in the integration brings greater sophistication to the integration framework and touches a larger number of information sources within the enterprise.

An important aspect of this IMP is the dimensional control process flow proposed by DaimlerChrysler (see Figure 1), which summarizes the measurement issues in IMP and is the starting point for other applications department. Some important aspects of this process, applicable to the whole project are shown.

3.1 Inspection Data Exchange

Based on above discussion, one good solution could use STEP AP219 as the standard data for CAD/CAM software and DMIS as the standard data format for CMM operating software. Some mappings between AP219 and DMIS are necessary as suggested in Figure 2. Since AP219 is still at the proposal stage, the architecture of this model may be subject to changes in the future.

Since AP219 is still under development, direct data transformation from DMIS to STEP AP may also be helpful.

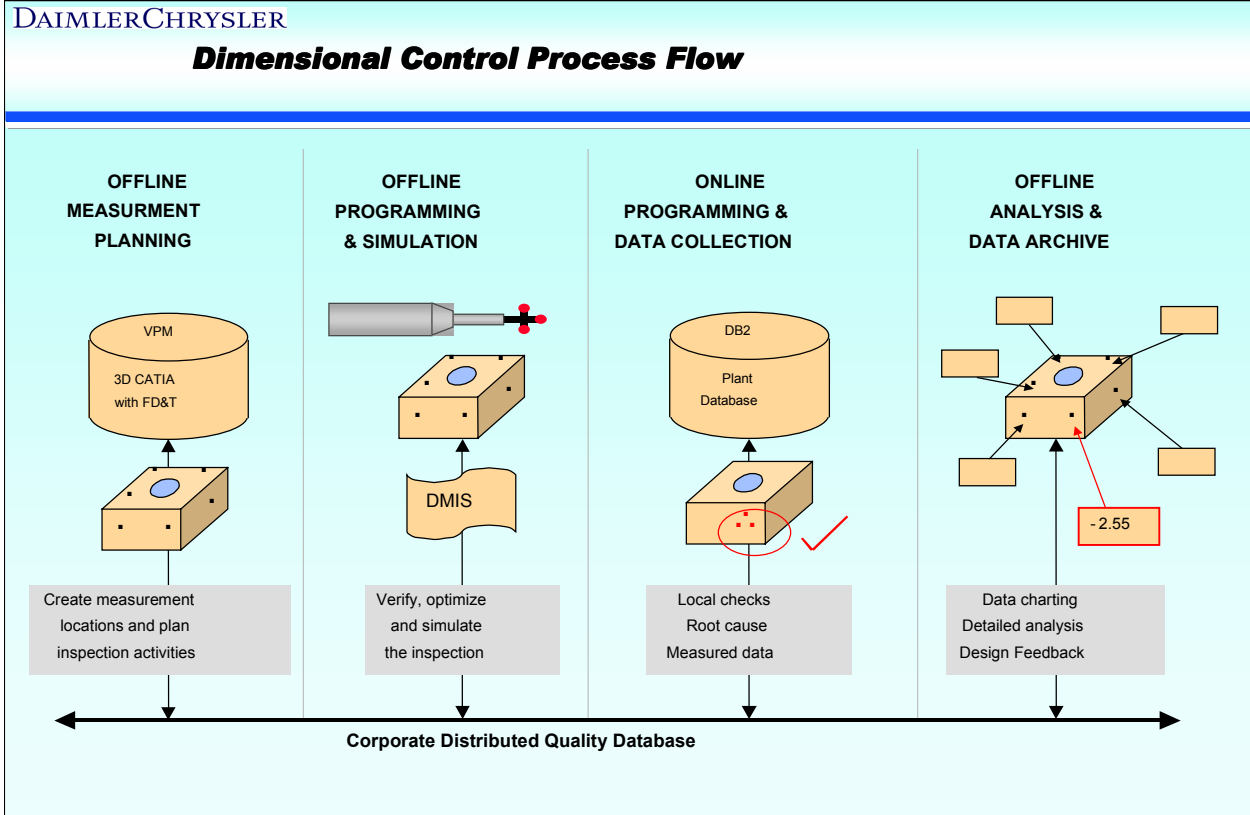


Figure 1. Typical Process Flow for Dimensional Control

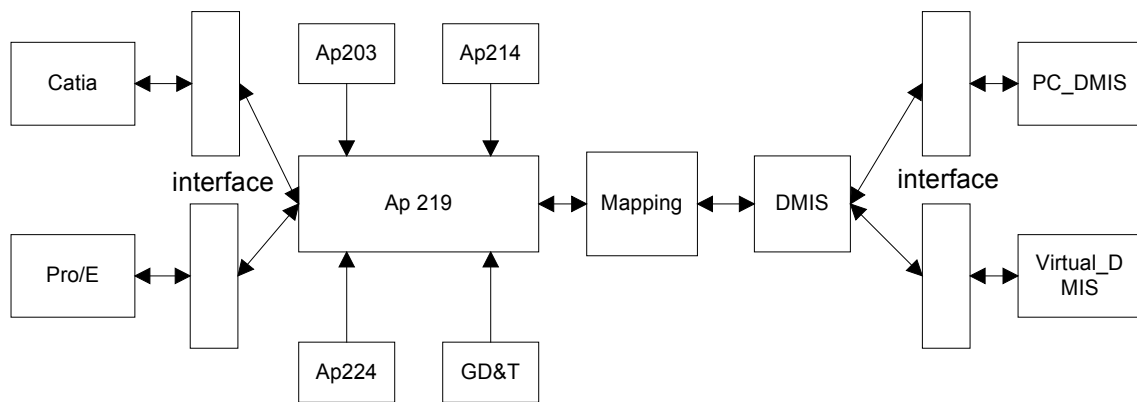


Figure 2. Adapter Model for Data Exchange

3.2 Data Representation

The AIM for each STEP AP is written in the EXPRESS language while XML/XSL/DTD is a more suitable neutral data format solution for communication among heterogeneous applications. Hence, a conversion process is needed to turn the EXPRESS schema into an XML/DTD data format. Early-binding-based conversion is a candidate solution for this issue. The resulting DTD using this method is robust and complete with respect to the product data semantics and constraints in the EXPRESS schema.

In a typical enterprise application, one or several databases may be used to store different kinds of information. The design of applications and databases must address the issue of partitioning, storing, and accessing these different data. An intuitive approach is to store the data in the lowest physical level objects (e.g. AIM entities) though this may cause a large database and make the operations inefficient. The use of some intermediate level of granularity, called Units of Functionality in object-relational database design, appears to be a better candidate solution.

3.3 Data Usage and Sharing.

This part mainly deals with types of analysis and how efficiently different application departments in an enterprise can use the measurement data. The data mentioned here not only refer to the discretely measured point data, but also the measurement program. Two main factors will be considered here. One factor is to consider algorithms to analyze the data based on functional requirements while another is to consider the overall structure of data flow and how the data flow can efficiently and correctly travel among or even outside enterprises. Some distributed component deployment technologies may be used to address this problem.

4. Measurement Uncertainty and IMP

Measurement uncertainty is a long-standing topic in coordinate metrology. Each complete measurement value must be reported with its uncertainty. There are several components contributing to measurement uncertainty that include machine components, probe components, part components and repeatability components. Among them, the measurement uncertainty caused by repeatability components can be reduced by IMP since operator influence, thermal errors, errors in recording, and analysis variations may be compensated for or eliminated by an automatic measurement process. Also, IMP may produce a more efficient measurement and reduce the negative effects caused by environment influences.

5. Conclusions

In this paper, the idea of an integrated measurement process is presented. Several current available technologies that are useful for this project are described. Important research issues in this project are discussed and some conceptual solutions and frameworks are presented. Also, the relationship between IMP and measurement uncertainty is discussed briefly.

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