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Novel Approach with 3D Measurement Data Management for Industry 4.0

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Abstract. The introduction of virtual product data and predominantly the usage of Computer Aided (CAx) Systems have fundamentally transformed product development. In particular, using 3D CAD and PLM systems yields to higher productivity, better quality and a simultaneous reduction of overall development time and costs. As one of the most important integration tasks for process chains, the implementation of a drawlingless process chain is a key topic in the automotive supply chain. Efficient measurement data management is an important step towards completion of this process chain. To addres this issue, a project group entitled "3D Measurement Data Management" (3D MDM) was set up in 2016 under the joint auspices of the VDA (German Association of the Automotive Industry) and the ProSTEP iViP Association. In this paper we illuminate the background of the digital transformation, and introduce the term Inspection PlusPlus Data Management Services. We highlight the specific needs and expectations of the automotive industry to 3D MDM. We describe the development approach, based on a framework successfully practised in more then 20 years. This article provides an introduction to 3D measurement data management and describes the challenges that this project group faces and the group's aims.

Keywords. Digital Transformation, Engineering Collaboration, Measurement Data Management, Inspection PlusPlus, Industry 4.0

Introduction

Product quality describes properties of a good in market which determine fulfillment of customer requirements. Manufacturers have product quality assurance units which control the produced quality. Rapid and seamless exchange of information is becoming increasingly important in order to preserve the quality of processes and products [1]. As a building block of interdisciplinary data management, the need for powerful measurement data management (MDM) arises [2]. An comprehensive MDM provides among others the potential for an enhanced automation of all operations, consistent quality control, increased efficiency of singular process steps and improved early risk identification [3].

A powerful product lifecycle management (PLM) comprises the support of product quality characteristics from the early design phase to late quality processes in the production. By the intelligent handling of geometrical dimensions and tolerances (GD&T), product manufacturing information (PMI) and measuring point definitions a

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paperless product quality management is possible [4]. That is a pre-requisite for a quality management which fulfills the requirements of Industry 4.0 [5]. That is still a challenge for the current PLM infrastructure indeed.

In spite of the unbroken trend towards digitalization, relating to the consistency and data exchange, in measurement process, still a large paper-burden is determined [6]. In particular in measurement planning, the necessary information is reported incompletely and inconsistently. Here, the absence of standardized interfaces is noticeable. The capability of the standard ISO 10303 (STEP) is not enough here (Fig. 1) [7].

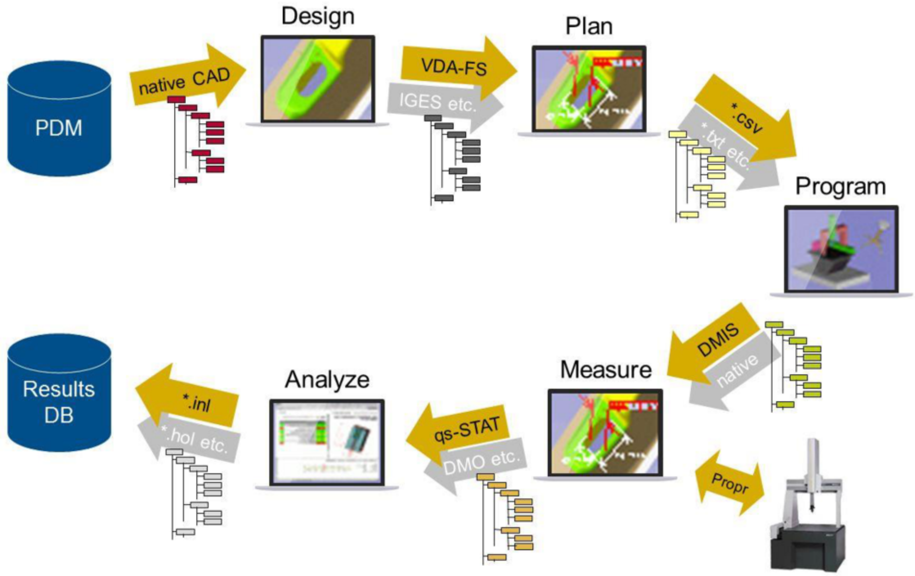

Figure 1. Interfaces in a typical measuring process.

By using a cross-functional connection of singular process steps with their domain-specific interfaces, a strong optimization potential is opened up. Therefore, the demand for a consistent digital availability of product features in particular concerns the 3D measuring technology [8].

Today, in the automobile industry, plethora of different measuring devices and methods are used to secure defined product quality [9]. For this, a high number of devices and processes are applied that differ in their functional characteristics, in their performance but as well concerning the level of their integrability into the cross-functional PLM processes [10].

Taking in mind the high number of different measuring devices for the most diverse requirements currently used in the automotive industry – and in other domains, the efforts of the users to harmonize the processes and methods is quite understandable. Especially for the use of measuring devices in the automated production, integration is required not only in the material flow but as well in the information flow of the production [11]. The integration of measurement technology into the manufacturing process further allows to faster determine and more efficiently use measured values, so that the measurement information is directly available during production e.g. for re-adjustment of devices and tools [12]. An automated data exchange realizes an additional efficiency enhancement [13].

A standardized interoperability of quality data between the particular system components shall enable the users to act flexible concerning the selection of hard- and software and to ensure a smooth data flow within the factory walls as well as with suppliers and customers [14]. To reach the named goals, a complex object model is required that includes, apart from the product model, the devices and tools as well as the relevant test and tolerance data respectively PMI and their relation to 3D geometry [15].

The structure of the paper is arranged as follows: Section 1 briefly introduces need for action. Section 2 describes the solution approach, in particular the Inspection PlusPlus initiative. The concluding remarks are presented in Section 3.

1. Need for Action

To tackle the challenge of transdisciplinarity in this issue, a collaborative project group entitled “3D Measurement Data Management“ was set up in 2016 under the joint auspices of the VDA (German Association of the Automotive Industry) and the ProSTEP iViP Association in order to address this issue comprehensively [16]. This group is composed of the representatives of original equipment manufacturers (OEM) as well as their main suppliers [2].

Such an approach and structure have been successfully proven for several times on integration topics in the past 20 years. Such a group represents the most important stakeholders and actors. Then they collect the requirements and use cases, and subsequently undertake their weighting and priorization. As result of their collaboration, various recommendations emerge.

This article provides an introduction to 3D measurement data management and describes the challenges that this project group faces and the group’s aims inside the ProSTEP iViP community which currently comprises 180 international members across the globe.

A variety of measurement methods and equipment are used in the automotive industry today to ensure the specified level of product quality [17]. These differ in functional properties such as way in which data is collected (contact or noncontact), the way in which measurement data is processed and in the level of integration with manufacturing equipment [18]. In addition to typical properties such as precision and speed, their performance also differs in terms of the degree to which they can be integrated in cross-domain PLM processes. The multitude of devices and processes found in the automotive industry has always provided fertile ground for the harmonization of processes and methods [2].

The desire for a standardized interface for the flexible design of the measurement process, with its numerous participants and objects, is therefore a logical consequence. It requires a complex object model that not only includes the product model but also the equipment and tools, as well as the relevant test and tolerance data (part of what is referred to as the product and manufacturing information (PMI) and its relation to the 3D geometry) [19].

In view of the increasingly drawingless quality process, the digital master approach also plays a key role in this context [6][2]. The digital master enables the enterprise to collects, maintains and provides all system information at a dedicated point in time to all actors. Digital master baselines allow traceability for all system elements.

Cross-domain data management also gives rise to the need for comprehensive measurement data management [20]. Subsequently, factors such as data-related recording, digital master, control of the measurement process, as well as IT systems and corresponding interfaces play a role. Companies are hoping that this will bring about an increase in the level of process automation, improvements to the change process, further stabilization in the process, consistent quality statements, enhanced performance in individual process steps, as well as the early identification of all risks before they become a problem. This challenge was recognized a number of years ago in the automotive industry and was taken up by the Inspection PlusPlus (I++) initiative, a consortium of seven European automobile manufacturers [21]. This will be used as the technological basis for our work.

2. Solution Approach

I++DMS is an interface definition involving Audi, BMW and VW, that was published in 2009 with the aim of exchanging information between software applications in the field of dimensional quality assurance. It covers the areas design, planning, programming, analysis and execution in the quality process of the automotive production [22]. It is planned to transfer the gathered experience to other industries (e.g.) aerospace [23].

Version 2.0 of I++DMS takes a service-based approach and consists primarily of a UML information model and an XML schema for its accurate description and has been available since June 2014 [22]. Initial implementations are being used in the quality management systems operated by German automotive OEMs. The data is not typically exchanged directly between the data-producing and the data-consuming systems but rather via an intermediate layer for persistent data storage. In addition to the data management services, the I++ initiative has, with the I++DME, also developed a widely used specification for communication between the measurement equipment and the measurement software (Fig. 2).

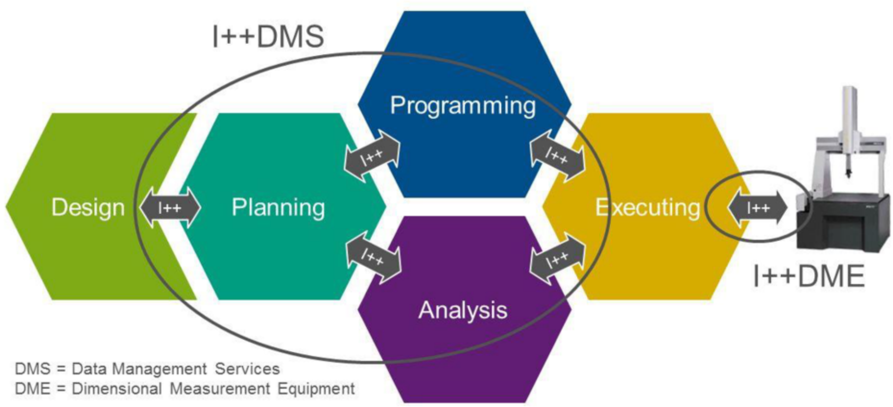

Figure 2. Definition of interfaces I++DMS and I++DME.

I++DMS has not yet been able to sufficiently establish itself as a standard in the extremely complex measurement process. Implementation of the measurement process involving many different manufacturers and components is therefore still being stretched to the limit – a limit that would vanish with the definition of a uniform interface. It is here that the project group set up by the VDA and the ProSTEP iViP Association comes into play. It is evaluating the current status of I++DMS with regard to its suitability as the standard format. As already done in precedent projects, a VDA Recommendation that makes available a revised version of I++DMS will be developed in an initial step.

The reference process created within the framework of the working group comprises not only inspection planning but also areas relating to measurement programming, measurements and analysis. This means that the I++DMS services can provide support for dimensional quality management throughout almost the entire process chain. The defined data structures are product structures that are relevant to manufacturing from the perspective of quality assurance (Product Structure) as well as inspection plans (Inspection Plan), inspection tasks (Inspection Task), measurements (Inspection), measurement programming (Inspection Program) and analyses (Analysis). Consideration of similar initiatives like Quality Information Framework (QIF) lies also in the scope of this working group [24][25].

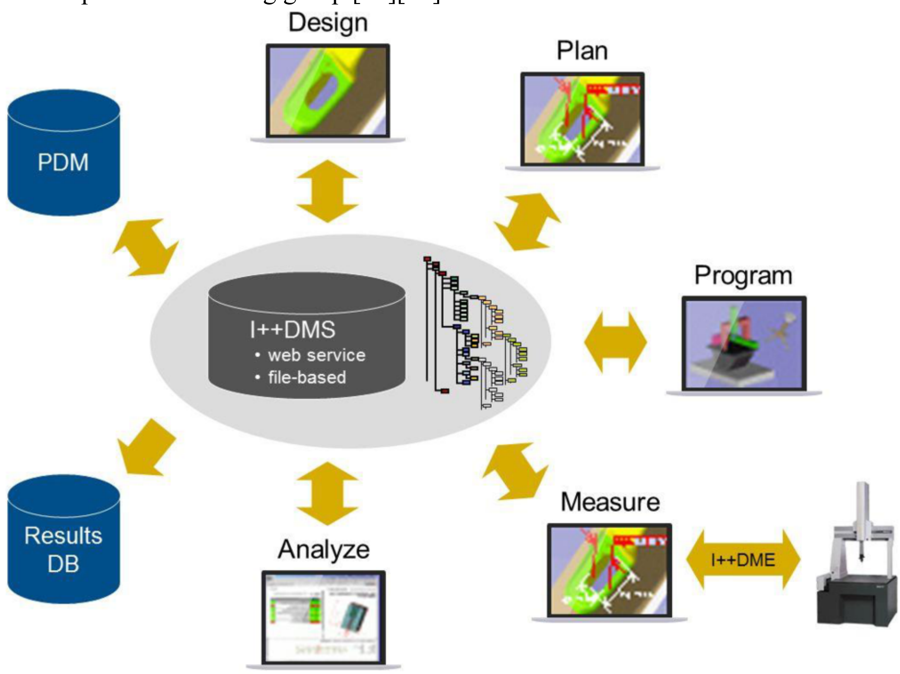

Figure 3. Vision of a measuring process based on an I++DMS data model.

Engineering, manufacturing planning and tolerance analysis are the prime sources of data for planning the features to be inspected. This data is not exchanged directly in I++DMS, but it can be assigned logically to the I++ entities by means of keys/foreign keys (Fig. 3). I++DMS thus represents a powerful basis for implementing quality processes within the automotive industry. I++ serves for transfer of measurement data and related information only. I++ is no standard for data storage – the storage resp.

processing of transferred data occurs in the application which has implemented the corresponding web service operations implementiert.

The primary aim of the ProSTEP iViP Association's working group is the definition of an executable specification for managing measurement data based on the I++ data management services. I++ DME, on the other hand, does not fall within the scope of this project. The long-term collaboration of several OEMs in the I++ working group has shown that the problems and loads are of the same nature and that cross-OEM solutions can contribute to their elimination, which ultimately yields a win-win situation of all participants. Collaboration in this project group is going to deliver first binding results in the relatively short term, with intensive support from the singular OEM committees. The group is focusing on two use cases: the process chain involved in exchanging quality data (Fig. 4) and the exchange of quality data between an OEM and a supplier (Fig. 5).

In the initial project phase, the use case and the concrete need for action were analyzed by the users of measurement software: BMW, Continental, Daimler, Ford, Adient (f.k.a. Johnson Controls), Opel, Schaeffler and Volkswagen. In the second phase, the working group is approaching system vendors with the aim of deciding together with them how further development of this model should proceed.

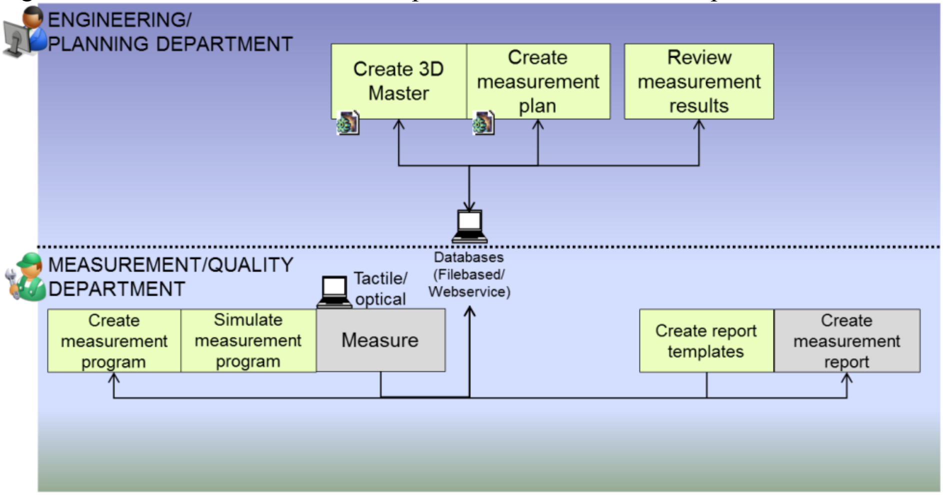

Figure 4. Process chain of an quality-related data exchange.

In line with a practice applied with great success in the ProSTEP iViP Association's working groups, the two different groups of participants, i.e. users and system vendors, will operate within the framework of two separate entities. The users will harmonize their requirements in the Workflow Forum, while the Implementer Forum provides system vendors with an opportunity to exchange information about the experience they have gained with the standard.

The project schedule provides that the working group will pass three consecutive project phases. It has started with the consideration of the following core tasks: quality features, tolerances, meta data. In the second step the following tasks follow: measuring strategies, measuring principles, and evaluation rules. The project should be finalized with the following tasks: measuring points, measuring procedures, evaluation layouts. Overriding aspects such as weaknesses in the data model and its specification, missing or incomplete use cases must also be taken into account.

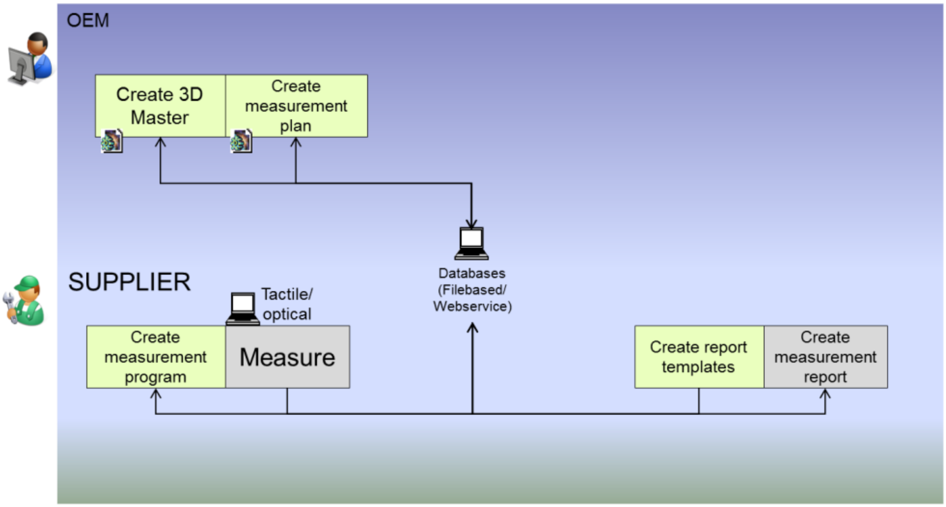

Figure 5. Quality-related data exchange between OEM and Supplier.

3. Conclusions and Outlook

Decisive for a high product quality is the early, rapid detection of all deviations in the production process. It supposes timely availability of input data (geometry and all related product manufacturing information). This requires a high level of consistency between the design, manufacturing and quality control, which must be supported by corresponding IT solutions. With the “3D Measurement Data Management“ initiative a new working group is initiated to close gaps in the area of manufacturing and quality control. The working group will also create an implementors forum which will take care for rapid implementation of the recommendations. With this structure, the project is intended to achieve the rapid progress and better transfer in the practice, following to the experiences of the similar initiatives.

It is intended that subsequent developments initially focus on the areas measurement strategies, measurement principles and evaluation rules. Consideration is also being given to the topics measurement processes and evaluation layouts. It is intended that both I++DMS and the VDA / PSI Recommendation will be adapted to these developments accordingly [26][27].

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