openZDM

Open Platform for Realizing Zero Defects in Cyber Physical Manufacturing

Mapping Industry Standards to AAS Submodels Using UML

The Asset Administration Shell (AAS) provides a standardized representation of different types of assets used in various Industry 4.0 applications. The set of properties defining an asset throughout its lifecycle is grouped into one or more submodels. Since it is necessary to represent an asset's properties over its entire lifecycle, properties from different domains must be specified. Additionally, Industry 4.0 scenarios require I4.0 components to communicate and cooperate with other components located within the company or externally in different organizations. Therefore, a proper definition of asset properties and characteristics is necessary. The relationship between input and output represents the model of the sensor and it can be represented by the general function given in Equation (1). This function can be determined through calibration.

The Industry 4.0 platform advocates for using standards, consortium specifications, or manufacturer specifications. Manufacturer specifications are individual descriptions that each manufacturer provides for specific asset properties without coordinating with others. Using such specifications may not guarantee interoperability with other AAS implementations. In contrast, consortium specifications involve a group of stakeholders who create and publish definitions of domain-specific concepts. Consortium specifications, such as eCl@ss, provide open access to standardized definitions, allowing these concepts to be used as AAS properties.

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Moreover, various Standard Development Organizations (SDOs), such as ISO, DIN, and IEC, provide definitions of properties that have been standardized through expert collaboration worldwide. Since using these standardized properties can ensure interoperability among AAS implementations, the openZDM project applied the VDI/VDE/VDMA 2632 standard for modeling Non-Destructive Inspection (NDI) systems.

The VDI/VDE/VDMA 2632 Standard in the openZDM Project

This standard describes principles and defines the terminology necessary for machine vision systems (MV systems). It ensures a consistent terminology even in intercompany environments. The objective in the openZDM project is to precisely describe the technical characteristics of NDI systems based on MV systems, facilitating standardized information exchange across platforms such as openZDM or between different digital solutions and data spaces.

In openZDM, only the first and second parts of the VDI/VDE/VDMA 2632 standard were used. The first part provides a basic introduction to machine vision systems, including terms and definitions. The second part outlines guidelines for preparing requirement and system specifications, ensuring effective communication between users and machine vision system providers. These standard definitions were used to create concept descriptions within AAS.

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The Importance of UML in Standard Modeling

To derive an AAS submodel from standards, the academic literature proposes black-box and white-box approaches. The black-box approach does not remodel the standard within the AAS submodel, reducing modeling effort but limiting interoperability across the asset lifecycle. Conversely, the white-box approach represents all standard information within the AAS metamodel, requiring greater modeling effort but facilitating implementation throughout the asset lifecycle.

UML provides a widely accepted visual modeling language used in industry to represent complex systems. UML describes various aspects of a system using classes, attributes, and relationships. Since the AAS metamodel is based on similar constructs, it is possible to map standard concepts to AAS concepts.

Methodology

The second part of the standard provides guidance on how clients should specify machine vision system requirements and how suppliers should define them. A mapping between related concepts from the requirement and specification documents was performed to determine the mandatory information that must be specified and its source. The requirement and system specifications should contain:

Influencing factors to be considered when preparing a requirement specification	Suggested contents of a system specification
Task	Associated documents and references
Test Object	Task
Scene	Description of the solution
Process Integration	Installation and commissioning
Human – Machine interface	Receiving and acceptance
Miscellaneous	Maintenance
	Planned project sequence

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Although the manufacturer should only take into account suggestions related to what the machine vision system specification should contain, user requirements are taken into account as a source of information on the data required to be specified. The structure of the system specification according to the VDI/VDE/VDMA 2632 standard is shown in Figure 1:

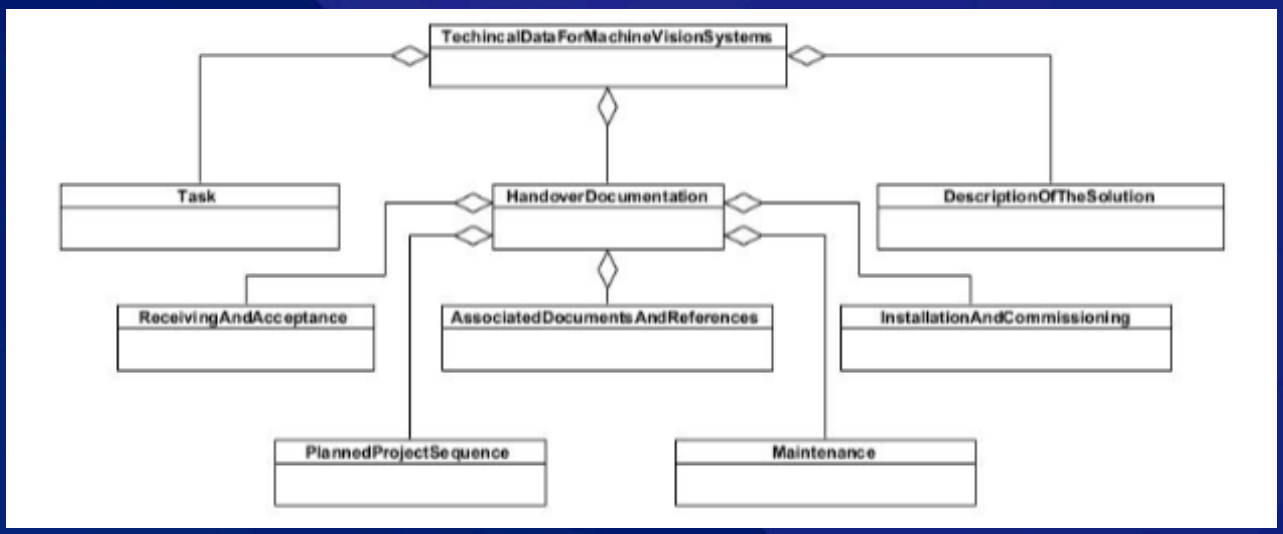

Figure 1. VDI/VDE/VDMA 2632 standard structure

After matching the attributes specified in the requirements and those to be specified, the proposed submodel should present the structure shown in Figure 2. In the figure it can be seen that the classes modelled in the diagram (e.g. Task) are mapped to the submodel element Collection (SMC) concept, which groups the set of attributes (mapped as properties) that must be exposed in the technical data specification of the asset. It can also be seen how the type of data required for the attributes match the data types that can be modelled through the Asset Administration Shell. Other elements of the Asset Administration Shell metamodel such as relationships were not identified in the VDI/VDE/VDMA 2632 standard, however, if they exist, they can be represented by the Relationship element concept of the AAS metamodel.

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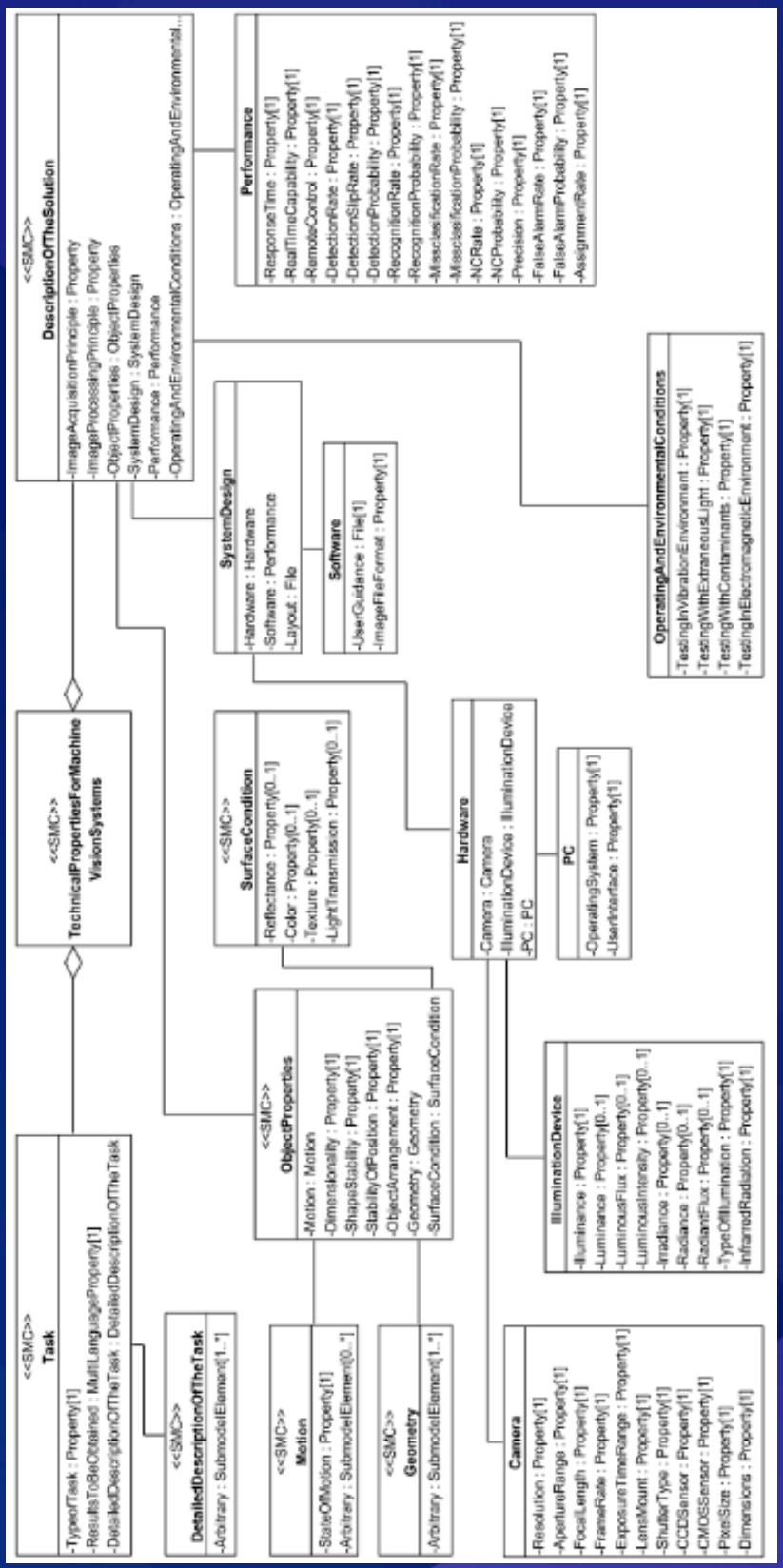

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Conclusions

The use of standards to create AAS sub-models is essential to ensure interoperability and efficiency in Industry 4.0. The implementation of sub-models based on the VDI/VDE/VDMA 2632 standard in the openZDM project has been implemented to describe Non destructive inspection systems based on AAS. In addition, the use of UML has facilitated the modelling, validation and verification of these submodels, ensuring their accuracy and functionality. Adopting standards-based approaches and leveraging UML not only contributes to the creation of effective digital twins, but also lays the foundation for the development of automated tools that enable model transformation and validation. Subsequently, modelled attributes have been proposed for standardisation in industry dictionaries, such as ECLASS, in order to be assigned a unique identifier (IRDI). A challenge to be addressed is the dissemination of the proposed sub-model and standardised properties, which would ensure the interoperability of the information exchanged across different platforms implementing AAS.

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