MODAPTO [101091996]: Modular Manufacturing and Distributed Control via Interoperable Digital Twins

13.3.1 Creating AAS submodels and properties for MODAPTO components

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Introduction

Creating AAS submodels and properties for MODAPTO components requires systematic approach to organizing asset information into logical, manageable collections that support both operational requirements and reconfiguration capabilities. The submodel creation process begins with comprehensive analysis of component characteristics, operational requirements, and integration needs to identify the most appropriate organizational structure for asset information.

The Digital Nameplate submodel serves as the foundation for asset identification and basic descriptive information. This submodel contains manufacturer identification, product specifications, serial numbers, and other essential information required for asset management and traceability. Various submodels such as the digital nameplate, the carbon footprint over the entire life cycle, technical data, and the asset interface description could all be integrated.

The Technical Data submodel provides comprehensive specifications that define component capabilities, limitations, and operational parameters. This submodel includes physical dimensions, weight specifications, power requirements, performance characteristics, and environmental operating conditions. For manufacturing equipment, technical data encompasses processing capabilities, accuracy specifications, tool requirements, and maintenance intervals that directly impact reconfiguration planning and operational scheduling.

The Capability Description submodel represents one of the most critical elements for MODAPTO implementations, as it defines what manufacturing operations the component can perform and under what conditions. This submodel includes detailed specifications of manufacturing processes such as welding parameters, assembly capabilities, machining specifications, or material handling characteristics. The capability description enables automated matching of component capabilities with production requirements during reconfiguration activities.

Process control and operational parameter submodels contain dynamic information that changes during component operation. These submodels include current operational settings, performance monitoring data, alarm conditions, and control interfaces that enable real-time management and optimization. The structure supports both read-only monitoring data and read-write control parameters that enable remote configuration and adjustment.

Maintenance and service submodels organize information related to component lifecycle management, including maintenance schedules, service history, spare parts specifications, and predictive maintenance indicators. Training resources ensure teams are proficient in using digital twins, with ongoing feedback and insights from digital twins used to continuously improve processes and asset management.

This information supports both planned maintenance activities and emergency response procedures while enabling optimization of maintenance costs and component availability.

Safety and compliance submodels address regulatory requirements, safety specifications, and risk assessments associated with component operation. These submodels include safety system interfaces, emergency shutdown procedures, personnel protection requirements, and regulatory compliance documentation. The safety information supports both normal operational procedures and emergency response planning while ensuring compliance with applicable safety standards.

Environmental impact and sustainability submodels capture information related to component environmental performance, including energy consumption patterns, carbon footprint data, waste generation characteristics, and end-of-life disposal requirements. Digital twins enable designers to assess environmental impact and resource usage of designs, promoting sustainable manufacturing practices by optimizing materials and energy consumption in virtual models to minimize waste and improve overall sustainability.

This information supports sustainability reporting requirements and enables optimization of environmental performance across the manufacturing system.

Business relationship submodels define connections between components and enterprise business processes, including cost accounting relationships, supplier information, warranty details, and service agreements. These submodels enable integration between technical asset management and business management systems, supporting comprehensive lifecycle cost analysis and strategic decision-making about component acquisition, utilization, and retirement.

Property definition within submodels requires careful consideration of data types, units of measure, semantic references, and validation constraints. Properties must be defined with sufficient precision to support automated processing while maintaining human readability and interpretability. Standard property definitions promote consistency across similar components while custom properties address specific organizational or technical requirements.

Semantic consistency across submodels ensures that related information can be effectively correlated and analyzed. This requires consistent use of concept descriptions, standard vocabularies, and naming conventions that enable automated processing and human understanding. Semantic references to external standards and vocabularies ensure that property definitions remain consistent with industry best practices and enable interoperability with external systems.

Hierarchical relationships between submodels support complex component structures where individual components may be composed of multiple sub-components, each with their own AAS representation. The hierarchical structure enables both detailed component-level management and system-level coordination while maintaining clear ownership and responsibility relationships.

Dynamic property management addresses the challenge of representing information that changes frequently during component operation. This includes mechanisms for updating property values, maintaining historical information, handling temporary unavailability of data sources, and managing synchronization between different data sources. Dynamic management capabilities ensure that AAS representations remain current and accurate under real operational conditions.

Validation and quality assurance procedures ensure that submodel definitions meet both technical specifications and operational requirements. Validation includes verification of data type consistency, range checking for numeric properties, semantic validation of relationships, and performance testing under realistic operational loads. Comprehensive validation reduces implementation risks and ensures reliable operation of reconfiguration systems that depend on accurate asset information.

References

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