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STANDARDS SUPPORTING SIMULATIONS OF SMART MANUFACTURING SYSTEMS

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ABSTRACT

Manufacturing standards provide the means for industries to effectively and consistently deploy methodologies and technologies to assess their performance. These assessments set the stage for controlling manufacturing systems and processes and enabling continuous improvement within the enterprise. Several evolving manufacturing-related standards impact the manufacturing simulation community and software vendors. This panel explores standards that enable modeling and simulation to play a larger role in manufacturing enterprises through tighter integration of simulation with manufacturing operations.

1 INTRODUCTION

Standards and best practices provide a foundation for ensuring the health, safety, and prosperity of the United States and the world. These standards lay foundations for modeling and integrating manufacturing systems and related services. The panel discusses several standards that are important for manufacturing and supported by stakeholders and supportive communities. Standards that are highlighted through a panel discussion include SysML and BPMN from the Object Management Group (OMG), ISA-95 and ISO 15746 standards for manufacturing automation and integration, ASTM International standards for manufacturing process characterization and sustainable manufacturing, standards for data-driven modeling and simulations from the Data Mining Group (DMG) and work items on codes and standards on Computational Modeling and Simulation for Advanced Manufacturing from ASME's Verification and Validation (V&V) committee, and the Simulation Interoperability Standards Organization's (SISO) CMSD standard. Potential collaborations on standards development, testing, and implementations can be explored.

2 THE STANDARDS

OMG standards: System Modeling Language (SysML) is a general purpose graphical modeling language for specifying, analyzing, designing, and verifying complex systems. Business Process Model and Notation (BPMN) is a graphical modeling language for specifying processes that is accessible to subject matter experts. Both languages are widely known and have many commercial implementations providing simulation capabilities. On-going research is focused on integrating these models with simulation capabilities.

Manufacturing automation and integration standards: ISA-95 is an international standard developed to automate the interfaces to connect enterprise application systems with the control systems that operate a manufacturing plant's equipment. This standard can be applied in discrete, batch and continuous process industries. ISO 15746, *Automation systems and integration – Integration of advanced process control and optimization capabilities for manufacturing systems*, is a new standard that is based on the ISA 95 hierarchy. It is intended to facilitate the integration and interoperability of software tools that provide automation solutions to advanced process control and optimization (APC-O) problems.

ASTM E60.13 Sustainable Manufacturing: Develops standards that manufacturers can use to benchmark, assess, act on and communicate performance metrics, including standards to characterize, evaluate, improve, and measure gate-to-gate processes in the production of finished goods.

Standards for data driven modeling and simulation of manufacturing processes: Two standards focus on the use of manufacturing data as it relates to simulation. The DMG's Predictive Modeling Markup Language (PMML) provides a way for analytic applications to describe and exchange predictive models produced by data mining and machine learning algorithms. In addition, ASME has formed a new subcommittee on Verification and Validation (V&V) in Computational Modeling and Simulation for Advanced Manufacturing. This group defines procedures for V&V and Uncertainty Quantification (UQ) in modeling and simulation for advanced manufacturing.

SISO's Core Manufacturing Simulation Data (CMSD) standard specifies the information entities common to manufacturing simulations to facilitate simulation model construction and data exchange between simulation and other manufacturing applications within a shop floor. Cases for testing and implementing CMSD will be discussed and illustrated.

3 CURRENT STATE OF IMPLEMENTATION OF THE STANDARDS

Standards will reduce the costs of incorporating talent into organizations by providing a common understanding of concepts, procedures, and tools. The maturity and adoption of the different standards varies. The OMG's standardization process requires commercial implementations along with the issuance of the standard. In the case of SysML and BPMN, there are quite a few implementations and OMG has workgroups for interoperability testing of these tools. BPMN is used to drive workflow engines, some tools follow related Workflow Management Coalitions specifications. At least some of the tools include APIs, though OMG does not standardize these APIs currently.

The ISA 95 standard has been around for some time and is used as both a reference model for describing manufacturing and related software systems and as the basis for interface specifications. The ISO 15746 standard has three parts. Part 1 is an international standard that defines a reference interoperability framework based on the ISA 95 hierarchy. Part 2 is a draft international standard that defines an information model of APC-O to enable integration of different applications and systems. Part 3 is a working draft that defines procedures for verification and validation of a APC-O system. , Even though many companies' APC-O implementations conform with the concept of the standard, since the standard is relatively new, more applications still need to be implemented and demonstrated.

The ASTM standards for sustainable manufacturing provide a basis on which manufacturing processes can be characterized and subsequently included in simulations. This has been demonstrated through research projects; however, due to the newness of these standards adoption is not yet widespread. These standards form the basis for standard descriptions of manufacturing processes that can streamline the representation of those processes in a variety of simulations. Research is on-going to demonstrate these capabilities.

PMML is supported by many analytics platform such as R, ADAPA, SAS, Python, MATLAB. Recent improvements to PMML includes two new probabilistic models—Gaussian Process Regression and Bayesian Networks—provide two critical pieces of information for manufacturing applications: confidence bounds and distribution for the predictive estimations. Both are needed to provide the foundation for uncertainty quantification analysis. The new activities in ASME's V&V community will define best practices for how these features will be used. These technologies will allow for more rapid deployment of simulation results into manufacturing operations.

For CMSD, Connecticut Center for Advanced Technology (CCAT) created tools that enabled the translation of manufacturing information organized according to the CMSD standard to non-standard representations supported by commercial tools. The tool supports an interface that uses CMSD as a neutral intermediate representation to integrate different commercial simulation and other analysis tools.

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