

## **STANDARDS SUPPORTING SIMULATIONS OF SMART MANUFACTURING SYSTEMS**

Kevin Lyons  
Conrad Bock  
Guodong Shao  
Ronay Ak

Engineering Laboratory  
National Institute of Standards and Technology  
100 Bureau Drive

### **ABSTRACT**

Manufacturing standards provide the means for industries to effectively and consistently deploy methodologies and technologies to assess process performance. These assessments set the stage for controlling the 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. Standards that are highlighted through a panel discussion include Core Manufacturing Simulation Data standard, ASTM E60.13 for sustainable manufacturing, SysML and BPMN from the Object Management Group, automation and integration standards: ISA-95 and ISO 15746, standards used in data-driven modeling and simulations including PMML from the Data Mining Group and new work items of codes and standards on Computational Modeling and Simulation for Advanced Manufacturing from a subcommittee in ASME's Verification and Validation (V&V) committee.

### **1 INTRODUCTION**

Standards and best practices provide a foundation for ensuring the health, safety, and prosperity of the United States and the world. Manufacturing standards provide the means for industries to effectively and consistently deploy the necessary measurement science to assess process performance. These assessments ultimately set the stage for controlling the manufacturing systems and processes and enabling continuous improvement within the enterprise. Several evolving manufacturing-related standards will impact the manufacturing simulation community and relevant software vendors. These standards lay foundations for modeling and integrating manufacturing systems and related services. This panel explores the role that simulation and modeling technologies play in developing, verifying, and deploying standards and reference data. The panel discusses several standards that are important for manufacturing and supported by stakeholders and supportive communities. Potential collaborations on standards development, testing, and implementations can be explored.

### **2 LIST OF THE STANDARDS**

The standards covered in this panel include

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

- Automation and integration: ISA-95 is an international standard developed to ease the automated interfaces necessary 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 optimization and advanced process control (APC-O) problems.
- Data driven modeling and simulation of manufacturing processes: Two standards focus on the use of manufacturing data as it relates to simulation. The Data Mining Group's (DMG) Predictive Modeling Markup Language (PMML) is an Extensible Markup Language (XML) -based predictive model interchange format and 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 of advanced manufacturing.
- The 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**

Other than the new work items, most of the listed standards have been implemented by commercial and industrial users in certain degree. For example, OMG requires commercial implementation as part of standardization, and in the case of SysML and BPMN, there are quite a few, judging by a web search for tools (OMG has workgroups for interoperability testing of SysML and BPMN tools). Some tools implement OMG standardized execution engines for portions of SysML. BPMN is used to drive workflow engines, some tools following related Workflow Management Coalitions specifications. At least some of the tools include APIs, though OMG does not standardize APIs currently. Web searches for manufacturing also turn up quite a few things, some commercial. SysML and BPMN are well known enough to reduce the costs of incorporating talent into organizations by providing a common basis for communication and innovation.

DMG is a consortium of commercial and open-source data mining companies, and is supported by many analytics platform such as R, ADAPA, SAS, Python, MATLAB. As an active member of DMG, National Institute of Standards and Technology (NIST) has contributed to the two new probabilistic models that appear in PMML v4.3: Gaussian Process Regression and Bayesian Networks. These new models provide two critical pieces of information - confidence bounds and distribution for the predictive estimations. Both are needed to provide the foundation for uncertainty quantification analysis. The models expressed in PMML aids predictive modeling and improve decision-making in engineering, manufacturing, and other industries.

For CMSD, Connecticut Center for Advanced Technology (CCAT) has 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 exposed an application programming interface (API) that enabled CMSD to be used as a neutral intermediate representation so that different commercial simulation and other analysis tools could be integrated.

#### **Disclaimer**

No approval or endorsement of any commercial product by the National Institute of Standards and Technology is intended or implied. Certain commercial software systems are identified in this paper to facilitate understanding. Such identification does not imply that these software systems are necessarily the best available for the purpose.