Simulation-Driven Systems Development (SDSD): Challenges, Strategies, and Opportunities for Success

CIMdata Commentary

Key takeaways:

- *Model-based, cross-domain engineering at the systems level is still in the very early stages of industry adoption, even within the larger OEMs in aerospace, defense, and automotive. In this respect, adoption of MBSE or MBE processes and tools is similar to the maturity level of mechanical CAD and CAE adoption beginning in the early to mid-1980s.*
- *Early adopters are starting to implement a more formalized and model-based approach to systems engineering within selected programs and domains, albeit not without the normal challenges related to major organizational and process change.*
- *Digital twins based on physics-based simulation models combined with analytics of real world operating data will open up many new business opportunities but will also require new business models with customers and partners.*
- *Progress in achieving the enterprise-wide digital thread and digital twin vision for tomorrow's complex cyber-physical systems must be based on a series of real world business successes based on focused engineering use cases within targeted applications areas with quantifiable metrics and repeatable business impacts.*
- *Systems development technologies and related data standards for systems architecture modeling, cross-domain data interoperability, model exchange, and long-term archival and retrieval (LOTAR) are maturing, but significant work remains in order to develop and agree upon a "must have" set of standards that are practical to implement by solution providers as well as truly beneficial to industry.*

SDSD Workshop Highlights

Participants from industry, government, and academia as well as solution providers attended the recent CIMdata Simulation Driven Systems Development (SDSD) Knowledge Council Workshop held at the UI Labs/Digital Manufacturing and Design Innovation Institute (DMDII) facilities in Chicago, IL on June 6 and 7, 2017. This annual CIMdata Knowledge Council Workshop was focused on the technical challenges, business opportunities, and implementation strategies for industry to define and achieve best practices for simulation-driven systems development within the context of the rapid digitalization of global enterprises.

With rapid advances in digital technology, the complexity of products is increasing exponentially due to "mass customized" product variants with high levels of software and electronics content. Game changing new product development and manufacturing technologies such as additive manufacturing, the Internet of Things, Industry 4.0, and "design to purpose" materials require new approaches to product development, manufacturing, and sustainment in operations (i.e. the digital thread/digital twin). As such, there is an increasing need to engage and collaborate across diverse engineering domains (mechanical, electrical/electronics, embedded software, controls, chemicals, materials, etc.) as well as with

other enterprise business functions (e.g., manufacturing, in-service operations) to develop better systems-oriented products and services-based solutions. The importance of digital modeling, simulation, and data analytics in enabling virtual experimentation that leads to insights into key product benefits and performance parameters throughout the product lifecycle is now becoming understood across all industries, not just in aerospace, defense, and automotive.

The one and a half-day workshop consisted of a series of keynote presentations by industry and CIMdata as well as interactive group discussion sessions moderated by the CIMdata SDSD Practice staff (Mr. Frank Popielas, Dr. Keith Meintjes, and Mr. Don Tolle).

During the course of the SDSD Workshop, speakers from industry and government presented their experiences with implementing model-based approaches across application domains covering commercial aircraft, defense systems, consumer products, automotive, heavy equipment, and others. Keynote sessions on current industry strategies, challenges, tools, standards, and best practices included presentations from:

- Mr. Brench Boden (CTO of DMDII, Technical Lead, U.S. Air Force Research Labs)
- Mr. Mark Williams (Lead Engineer, System Process & Tools, The Boeing Company)
- Dr. Andreas Vlahinos (President, Advanced Engineering Solutions, LLC)
- Mr. Roger Burkhart (Technology Architect, Deere & Co., Chairman of the joint NAFEMS/INCOSE Systems Modeling and Simulation Working Group)
- Mr. Mark Meile (Director, Modeling and Simulation, Procter & Gamble)

The CIMdata SDSD Practice staff presented and led discussions on digital thread and digital twins; collaboration standards for MBSE; organizational, people, and cultural issues in implementing MBSE; a potential MBSE maturity model framework related to CIMdata's Enterprise Application Architecture information model (see Figure 1); and Generative Design, a next generation integrated simulation-design-manufacturing process that leverages simulation and topology optimization with new additive manufacturing capabilities.

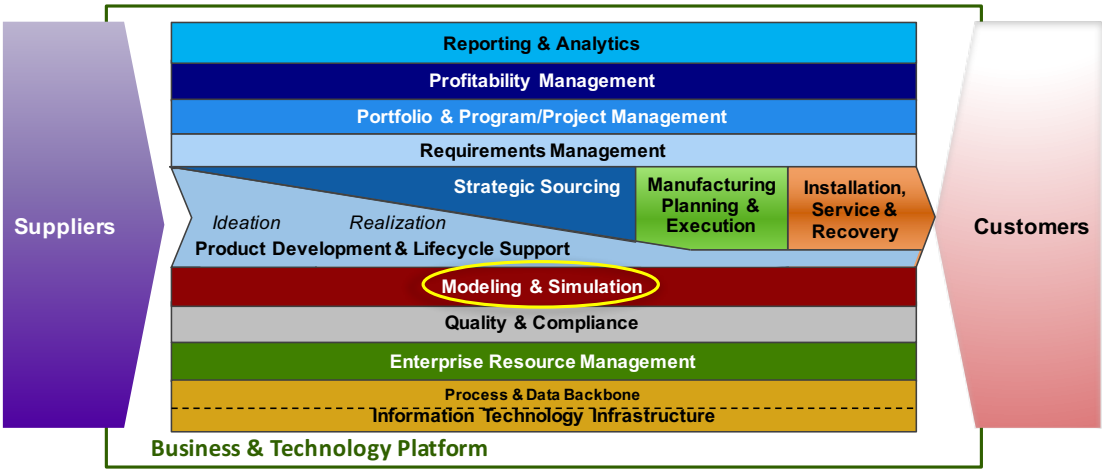

Figure 1—CIMdata's Enterprise Application Architecture Model

A number of key points around the adoption of model-based engineering approaches, technologies, and standards were raised and actively debated during the group discussions:

1. There was universal agreement and concern about the proliferation of MBx terms and hype around the area of model-based approaches to product development. It was widely felt that the use of MBx terminology within domain silos as well as across overlapping engineering domains and application areas (e.g. MBSE, MBEngineering, MBEnterprise, MBDesign, MBDefinition, etc.) both confuses and alienates senior management as well as the general engineering user community who must support and adopt the move from document-based to model-based processes and technologies. Without inventing yet another term, we might want to call it “Doing engineering in a much better way with the latest tools and processes.”
2. All the attendees acknowledged the significant people, cultural, and organizational challenges that exist in adapting today’s more ad hoc systems engineering best practices and widely used non-managed tools, such as Microsoft Office, into a collaborative, digitally-based MBSE framework. As with any significant process and technology change, to be successful there will be normal cultural resistance due to existing organizational processes as well as knowledge and information silos that run counter to the required collaborative nature of an MBSE-centric process. As such, the need for strong champions in senior management who remain continually engaged was identified as essential, as was a long-term commitment from all levels of management to invest the resources required to effect lasting process changes.
3. As with all enterprise change initiatives, developing a long-term vision, strategy, and implementation roadmap are key to success. Change introduces business risk, and that risk can only be addressed and minimized with well thought out requirements and a well-documented plan developed with input from all key stakeholders and communicated throughout the enterprise.
4. Ultimately, MBSE will not be successful unless it helps break down communication barriers among all the stakeholders in the systems development process. Realizing the benefits of having a common digital description for today’s complex systems and even systems of systems (i.e., defining, updating, and tracking requirements over time; identifying design gaps and inconsistencies to minimize engineering change; supporting re-use of modeling and design information within and across domains; increasing trade space exploration at the conceptual stage; improving virtual systems-level testing and validation; using digital twins for in-service maintainability and design upgrades, etc.) requires a next generation model-based approach. Status quo is not a viable alternative.
5. MBSE technical champions need to constantly ask: What application areas will provide the most immediate business impact? What is the measurable business benefit of changing to a model-based approach? What are the benefits for the users of the MBSE technology whom we are asking to make the process change?
6. Success breeds success, which leads to widespread adoption of change. Start small and pick the application areas where you can clearly answer the three questions above. The formula is “Crawl...Walk…Run.” Don’t try to boil the ocean.
7. Modeling and data interoperability standards have a very checkered past in the PLM/CAD/CAE industry. Far too many “non-standard standards” exist today that were never really used even in specific sub-segments, let alone by a wide cross-section of industry end users. Commercial software solution providers will and must invest the R&D efforts necessary for industry to leverage MBSE standards across PLM/MBX tool platforms. However, standards can only be successful if industry sends a clear and consistent message that the selected set of standards are “must have” for their businesses to operate and for the tools of the solution providers to be approved for consideration during the software acquisition and on-going license renewal process.

8. The business benefits of the digital twin concept are not well quantified and understood by the industry today. There are practical technology implementation issues such as simulation model size and fidelity required for real-time, systems level co-simulation as well as practical business issues such as who actually owns the performance data being captured from an in-service digital twin.

The bottom line observation from the CIMdata SDSD team is this: As with all new processes and technologies, achieving MBSE will be a marathon, not a sprint. It took the industry over 35 years to move from 2D drawings to mechanical 3D CAD, CAE, and PDM as a standard way of doing business for detailed product development. Achieving complete product lifecycle management (PLM) via MBSE and the digital thread will hopefully happen much more quickly than that, but it will definitely take considerable time, effort, and management patience.

Therefore, do not expect instant gratification but do demand measurable and continuous progress. As noted in the SDSD Workshop discussion points above, the key to real progress will be a disciplined "success breeds success" approach with a focus on a number of well-defined MBSE application use cases that provide visible and measurable business impact to the global digital enterprise. The fabric of the digital thread will have many strands that interweave across functional domains, and tomorrow's PLM-MBSE platforms will need to connect many types of models and data throughout the digital enterprise.

The CIMdata Simulation-Driven Systems Development Knowledge Council will continue to track, research, and report on the key model-based engineering processes and modeling and simulation technology issues raised and discussed during this annual workshop, as well as other topics of interest to the systems modeling and simulation communities. CIMdata SDSD Knowledge Council members will have access to the SDSD Workshop presentations and other SDSD Knowledge Council research deliverables via the CIMdata PLM Community member website.

For further details on the activities of the SDSD Consulting Practice, SDSD Knowledge Council, and annual SDSD Workshop, see http://www.cimdata.com/en/research/.

About CIMdata

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