

Simulation-Driven Systems Development Knowledge Council

Enabling the Vision for Model-Based Systems Engineering Enterprise Membership

CIMdata’s Product Lifecycle Management (PLM) Knowledge Councils conduct in-depth research for both industrial organizations and PLM solution providers. They emphasize strategic as well as practical, tactical options for companies to follow as they further adopt PLM.

PLM as defined by CIMdata encompasses the full systems lifecycle, from concept ideation thru product realization and in-service to end of life including recycling and reuse. PLM supports the extended enterprise in the collaborative creation, use, management and dissemination of all product data and intellectual assets.

The research defines best practices for topics of interest to industrial companies who use PLM to support their ongoing product development business strategies and for PLM solution providers interested in understanding and defining their PLM strategies and directions, and associated offerings.



CIMdata currently offers six PLM Knowledge Councils, as shown in the figure above. Council topics are developed from CIMdata’s PLM Community as technology evolves and industry requirements dictate. Additional information related to CIMdata’s PLM Community is located at www.CIMdata.com.

Simulation-Driven Systems Development Knowledge Council

Simulation-Driven Systems Development (SDSD) is an interdisciplinary set of methods and solutions that enable the realization of successful systems. This includes the simulation and validation of systems performance through the use of advanced modeling and simulation (M&S) strategies applied to both products and manufacturing systems, providing decision support over the entire product lifecycle from ideation through life.

A full system is much more than just the product design; it covers the product lifecycle, encompassing the whole of product development, product production, maintenance and support, through product life and retirement (i.e., recycling, disposal, repurposing, etc.). Simulation-driven systems development focuses on identifying and capturing customer needs and quantifying engineering requirements in terms of required product functionality early in the development cycle, digitally documenting and tracing those requirements, then proceeds with design synthesis and system simulation and validation while continuously considering the complete lifecycle and all of its many facets. This approach seeks to integrate all the disciplines and specialty groups involved in a system’s development into a team effort forming a structured development process. Simulation-driven systems development considers both the business and the technical needs of customers, with the goal of providing high quality and innovative systems that meet the users’ needs, and develops products in an optimal manner that maximizes an organization’s return on investment.

The Simulation-Driven Systems Development Knowledge Council helps to define and benchmark industry best practices for integrating data, processes, tools, and people across all domains that have an impact on the product development process, including mechanical, electrical, software, control systems, chemistry, optics, and other physics. This multi-industry effort focuses on the cross-domain collaboration necessary to integrate engineering development specialties that currently fragment product ideation and realization efforts. The Council identifies and prioritizes requirements

and capabilities for simulation-driven, model-based systems engineering strategies, best practices, and enabling solutions.

The SDDS Council is comprised of participants from both industrial companies and PLM, ALM, simulation and analysis, and MBSE solution providers, enabling cross pollination of ideas between the user community and those trying to supply integrated and open platform solutions. The SDDS Council's participants are drawn from many industrial segments to foster sharing of practical implementation experiences and lessons learned.

The Council identifies and prioritizes requirements and capabilities for simulation-driven systems development strategies, best practices, and enabling solutions.

Specifically, the SDDS Council focuses on simulation-driven systems design in which systems-level performance modeling and simulation are used in conjunction with logical and functional system architecture definitions, legacy design knowledge, FMEA, and empirical test data to define optimal physical system design alternatives starting in the concept development stage that are then continually verified and validated to confirm performance to requirements as the system details are refined at the sub-system and component levels. Upfront capabilities for trade studies (multi-domain, multi-physics, and multi-scale) as well as model-based collaboration will enable concurrent engineering across the functional domains inherent in today's complex cyber-physical systems (mechanical, electrical, and software and controls).

The SDDS Council also supports the definition and advancement of a product innovation platform of platforms approach—an integrated yet open environment that provides the tools and processes necessary to manage access to M&S applications, data, processes, and IT resources including high performance computing. The M&S framework needs to manage the complexity of multi-disciplinary system-level product performance, and integrate with other elements of the broader PLM environment, including requirements, functional, logical, and physical architectures (RFLP), product geometry, test, manufacturing, reliability, and cost information. The low level of PLM maturity at many companies today presents a significant problem in defining, deploying, and integrating such an M&S framework for SDDS.

The SDDS Council is also concerned with the people and process aspects of implementing MBSE in addition to the supporting software and IT technology. Simulation Governance provides a strategy to make simulation repeatable, reliable, and robust to provide critical decision support for a wide range of users and customers. Best practices and capability assessments provide a basis to leverage simulation for a sustained competitive advantage.

Council membership is structured to include the world's leading manufacturing companies as well as a broad range of commercial solution providers. The active participation of

these members enables strategic alignment between industry needs and available and future commercial solutions.

SDDS Knowledge Council Member Deliverables

Simulation-Driven Systems Development Workshops

To facilitate open dialogue and advance industry's adoption of PLM and MBSE technology, the SDDS Council provides a highly regarded forum for face-to-face discussions and knowledge sharing among industrial companies and PLM and MBSE solution providers.

CIMdata's workshops and conferences encourage and enable leading industrial companies and solution providers to discuss the major issues involved with implementing simulation-driven systems development. With both industrial companies and solution providers actively engaged, these workshops provide an opportunity for the solution providers to identify and prioritize critical technology gaps that limit true cross-domain analyses and inter-relationships among mechanical, electrical, software and control systems, and other factors that need to be considered when designing a product as a system of systems.

With the co-operation of leading industrial users participating in the SDDS Council, case studies are shared to provide guidance on strategies for the utilization of simulation-driven systems development concepts in the product development process, and for successful deployment to overcome organizational resistance to change.

Simulation-Driven Systems Development User Surveys

Web-based surveys on industrial best practices in key simulation-driven systems development disciplines such as requirements management, cross-domain collaboration, PLM metrics and benefits, innovation, and other topics of interest to SDDS Council members have been conducted in the past by CIMdata and will be an on-going aspect of the SDDS Council.

Simulation-Driven Systems Development Maturity Models

CIMdata has developed a number of maturity models over the past three decades addressing many different aspects of PLM. Maturity models can identify critical issues related to the integration of engineering disciplines, requirements, embedded software, electronic, and mechanical designs into overall system solutions. These maturity models help evaluate the maturity level of participating companies by leveraging multi-level ranking approaches applied to each of the defined performance criteria. Measuring an organization's maturity is not only a way of ranking its current capabilities, but also

provides actionable recommendations that will help the organization improve its maturity.

Each maturity model investigates a specific set of criteria established collaboratively by members of the SDSD Council targeted at an area of interest. These evolve over time through active discussions and on-going research.

In 2017, CIMdata intends to develop a focused Simulation-Driven Systems Development maturity model to evaluate critical issues and best practices related to creating complex systems comprised of electronics, controls, mechanical, software, chemical, optics, and other physics. This initiative will engage representatives across a range of target industries, technical domains and MBSE-related technologies.

Based on review and feedback from SDSD Council members, this Simulation-Driven Systems Development maturity model will be developed in stages and refined with additional focus over time across all of the model-based systems engineering domains and technology capabilities. Once developed, the Simulation-Driven Systems Development Maturity Model will be available for SDSD Council members to use for their own evaluations of simulation-driven systems development maturity.

Simulation Governance

In recent years the concerns of Council members to make physics-based behavioral modeling and simulation more effective have resulted in consulting projects and research studies on how to properly manage simulation activities.

Consistent with the rapid movement towards model-based systems engineering, simulation and analysis is one of the fastest growing segments of the PLM market. This growth, and the increasing reliance on digital modeling and simulation to support product development decisions, underscores the need for a governance framework to manage systems modeling and simulation as a strategic capability that extends across engineering domains over the entire product lifecycle.

Governance is a structured way to develop and ensure technical competence. The focus includes capturing and re-using best practices, standardized work processes, embedded quality assurance, as well as the integration of product development with manufacturing and collaboration across the extended enterprise.

CIMdata leverages its expertise in developing maturity models as well as related Return on Investment (ROI) models to enable our SDSD Council members to define and implement M&S Governance strategies and document how they can drive effective systems and product development.

Current SDSD Council Research

The SDSD Council promotes the adoption of a next generation model-based systems engineering environment—a collaborative, cross-domain environment that provides tools to effectively manage access to SDSD applications, processes,

knowledge, data, and computing resources. Such an environment is required to manage the complexity of multi-disciplinary system-level product development decisions and integrate MBSE with other elements of the product design environment, including 3D product design, configuration management, performance simulation, costing, manufacturing, logistics, in-service operations, product life extensions, etc.

Knowledge capture, requirements management, process automation, simulation and analysis, and data management are necessary elements to support systems engineering traceability, quality control, and collaboration for system-level multi-disciplinary product development optimization. The relatively low level of PLM maturity at many companies presents a significant problem in defining, deploying, and integrating such a simulation-driven systems development process today.

The critical requirements for users of PLM, MBSE, and M&S technologies need to be clearly identified, prioritized, monitored, and continuously updated. Leading global industrial companies participate in CIMdata surveys to better understand the current context and priorities for collaborative, in-depth product design that help to shape decisions more effectively. The SDSD Council approach concentrates on those priorities that can be defined and addressed within one to three years. The results are published in reports available to members of the SDSD Council.

Under the guidance and prioritization of its collaborative members, the Simulation-Driven Systems Development Knowledge Council's research agenda for 2106 will concentrate on one or more of the following critical issues:

- **Requirements-driven design and validation** The vast majority of industry uses a document-centric process for capturing and communicating high-level system requirements to downstream stakeholders in the product development organization. Even when software tools are used for requirements definition and capture, that knowledge and related data are typically not connected to the company's primary PLM environment(s). Functional decomposition of system-level performance requirements into appropriate performance targets for sub-systems and components are often incomplete and/or inadequate for final verification and validation of the design. These systems engineering process and data disconnects often result in a lack of traceability of the impact of downstream design decisions on the final product quality, leading to costly engineering change orders, delays in product launch and release quality issues.
- **Co-simulation as an enabler for model-based systems engineering of complex cyber-physical systems:** Model interoperability and co-simulation of systems and systems of systems will be critical going forward to achieve MBSE. The SDSD Council will address best practices for leveraging system-level (0D/1D) physical behavior models with software and controls and for sharing models

that enable collaboration across functional domains which are currently lacking.

- **Determining metrics for measuring MBSE success:** Through surveys and actual industry case studies metrics appropriate for measuring the financial impact and success of implementing an MBSE approach will be developed.
- **High-level requirements for integration of data and process management across ALM, PLM, MBSE, and other systems:** Each solution provider has a specific approach to systems engineering data and process management, and different categories of providers are currently extending their offerings in their domains with often overlapping and yet disconnected solutions. The SDCS Council analyzes these approaches and highlights key benefits for users.

Numerous MBSE standards such as AP209, AP233, AP239, AP242, and MoSSEC to name just a few are being promoted across industry and technologies such as UML, SysML, FMI, FMU, and OSLC are evolving to address the interoperability of data and system models.

- **Simulation process and data management:** Simulation is a critical enabler for model-based systems engineering. However, best practices for managing system-level (0D/1D) behavior models, including component libraries and configurations, and for sharing models that enable collaboration across functional domains are currently severely lacking.

As such, SPDM is also key to establishing simulation as a repeatable, robust and reliable capability, and to capture best practices and organizational knowledge (intellectual property). In spite of wide availability, adoption of these tools by end users has been slow, even in the area of 2D and 3D applications. The SDCS Council will continue to assess best practices for SPDM and to help document use case, best practices, tools and infrastructure, requirements, business cases, and metrics for effective SPDM implementations.

- **Culture change and organizational resistance:** SDCS is just one component of many companies' drive to a complete digital definition of their products and their development processes. Such efforts often encounter significant change resistance and require concentrated efforts to foster adoption, manage change and provide training of people who will be the champions and early adopters of implementing MBSE approaches.

The SDCS Council will participate in the definition and publication of strategies for the most effective use of systems engineering and simulation and their integration into the overall PLM environment.

Knowledge Council Offerings¹

2017 Events

- PLM Road Maps™ 2017
- US Workshop

Publications

- Publications and reports related to the SDCS Council, including archived reports
- Any maturity models developed from the research of the SDCS Council

PLM Presentations and Audio from PLM Road Map

All presentations from PLM Road Map events are provided.

Enterprise Membership

Corporations who sponsor the Knowledge Council include both industrial companies and solution providers. Enterprise members receive the following benefits:

- **Knowledge Council Participation**—participation in Council surveys and discussions that help drive and shape the critical issues that are researched.
- **Knowledge Council Registrations**—two free registrations to CIMdata-organized Council events (e.g., Council workshops, webinars, briefings, and teleconferences). Additional registrations for the Council Workshops are available at a discount.
- **CIMdata 2016 PLM Market Report**—one market analysis research report (MAR), selected by the Knowledge Council leader, that provides CIMdata's estimates of PLM solution provider revenues for 2016 and 5-year forecasts for the overall PLM market and its key segments, including Tools, cPDM, and Digital Manufacturing. Tools sub-segments include MCAD, CAM, S&A, EDA, and AEC.
- **Two Named Users**—Named Users are designated contacts who receive direct mailing of the Late-Breaking News and other publications, and who are authorized to contact the Knowledge Council leader. Two named users receive all Council deliverables. Additional Named Users may be added for a fee.
- **Corporate Use License**—members receive a worldwide license to distribute CIMdata-provided news and authorized publications throughout their organization for internal use. Named Users may forward or post these to colleagues within their company. This license does not imply nor include any right to perform language

¹ Selected presentations and audio from all of CIMdata's PLM Knowledge Council activities are available to SDCS Council members for download.

translations of CIMdata copyrighted materials as any translation must be performed, approved, and released by CIMdata.

- **One CIMdata Commentary**—commentaries are CIMdata-authored papers on mutually agreed upon topics that provide CIMdata’s independent review of some aspect of the member’s activities related to the Knowledge Council’s research areas. CIMdata will present comments and opinions on why the selected topic is noteworthy to the larger market. The objective, topic, theme, outline, and promotional plan of the commentary shall be developed in collaboration with the member. Each commentary will be up to three pages in length and will jointly be published, distributed, and promoted.
- **PLM Road Map™ Conference**—members are entitled to two registrations to a CIMdata PLM Road Map conference held within the membership year. These registrations are limited and may not be used by sales and marketing personnel. Additional registrations are available at a discount.
- **PLM Late-Breaking News**—a daily newsletter that provides breaking news on PLM market activity, product announcements, industry events, financial investments, solution providers, and industrial users, along with CIMdata’s latest commentaries providing insight and analysis.
- **PLM Industry Summary**—a weekly compilation of news that is the most comprehensive and longest running digest focused exclusively on the PLM industry. Extensive archives of industry news and product announcements are maintained online at CIMdata.com.
- **Market Update Webcasts**—quarterly members-only broadcasts provide CIMdata’s insights on notable developments in the many technology market segments within PLM, along with updates on CIMdata research and member support resources.
- **PLM Community Participation**—members are invited to participate in CIMdata’s PLM Community, which includes the ability to add content or comment in CIMdata’s social media channels. Members may be selected periodically throughout the year to participate in opinion polls or leadership interviews that can provide additional visibility and recognition.
- **PLM Certificate Program Attendance**—members receive one no-cost registration to attend the first two days of a regularly scheduled public PLM Certificate Program. The CIMdata PLM Certificate program is an assessment-based PLM training class for industrial companies, software providers, consulting services firms, value added resellers, and system integrators. This registration is non-transferrable and is subject to the availability of space for the desired class. After the program, CIMdata will request that the attending student provide a short statement as to the value of the class for their organization. Attendees may upgrade to the full five-day class at an incremental cost.

- **PLM Certificate Program Discounts**—members enjoy special rates of 10% off list price in addition to volume discounts for multiple participants in PLM Certificate Programs.
- **Presentation at a CIMdata Event**—members may nominate a speaker or panelist in a CIMdata event or conference during the membership term, including CIMdata’s PLM Road Map conferences and Knowledge Council workshops.
- **Annual Strategy Session**—an annual one-hour web conference with CIMdata consultants to cover specific ongoing issues critical to the member company within the context of the Council’s research and purpose.
- **Publications Discount**—members receive 15% off the list price when purchasing CIMdata research reports and publications not included in the Council membership.

About CIMdata

CIMdata, an independent worldwide firm, provides strategic management consulting to maximize an enterprise’s ability to design and deliver innovative products and services through the application of Product Lifecycle Management (PLM) solutions. Since its founding over thirty years ago, CIMdata has delivered world-class knowledge, expertise, and best-practice methods on PLM solutions. These solutions incorporate both business processes and a wide-ranging set of PLM-enabling technologies.

CIMdata works with both industrial organizations and solution providers of technologies and services seeking competitive advantage in the global economy. CIMdata helps industrial organizations establish effective PLM strategies, assists in the identification of requirements and selection of PLM technologies, helps organizations optimize their operational structure and processes to implement solutions, and assists in the deployment of these solutions.

For PLM solution providers, CIMdata helps define business and market strategies, delivers worldwide market information and analyses, provides education and support for internal sales and marketing teams, as well as overall support at all stages of business and product programs to make them optimally effective in their markets.

In addition to consulting, CIMdata conducts research, provides PLM-focused subscription services, and produces several commercial publications. The company also provides industry education through PLM certificate programs, seminars, and conferences worldwide. CIMdata serves clients around the world from offices in North America, Europe, and Asia-Pacific.

To learn more about CIMdata’s services, visit our website at www.CIMdata.com or contact CIMdata at: 3909 Research Park Drive, Ann Arbor, MI 48108, USA. Tel: +1 734.668.9922. Fax: +1 734.668.1957; or at Oogststraat 20, 6004 CV Weert, The Netherlands. Tel: +31 (0) 495.533.666.

