New Frontiers

New Cultures

New Thinking

SMS_ThinkTank™

SYSTEMS MODELING AND SIMULATION (SMS)

A Brief Introduction

Edward A. Ladzinski, CEO & Co-founder
Phone: +1-704-254-1643
Email: ed.ladzinski@smsthinktank.com

Frank W. Popielas, Managing Partner & Co-founder
Phone: +1-630-423-2497
Email: frank.popielas@smsthinktank.com

Website: www.smsthinktank.com

SMS_ThinkTank™ LLC is the global resource and leader in systems modeling and simulation, bringing the worlds of systems engineering and computer aided engineering together.

Systems Modeling and Simulation (SMS)
A Brief Introduction

The complexity of systems across all industries is exploding with innovation, embedded systems and interactive environments accounting for an ever-increasing share of the total product cost, while at the same time ensuring a cost effective and reliable product is introduced to the market. For many OEMs and suppliers to remain competitive, a systems engineering culture and best practices, considering the new lessons learned from Systems Modeling and Simulation, should be adopted to address the increasing complexity in features requested by the customers. An additional major drive for the market is change towards an "experience-driven" economy / society where the consumer demands much more flexibility and choices introducing a time where "one size fits all" is gone.

By applying the understanding and appreciation of Systems Modeling and Simulation to the well-established systems engineering thinking, major challenges can be addresses when enabling new technologies and processes. Some of the major technologies for this fast-paced environment are:

- Model-centric Engineering (3D and other fidelity level models)
- Model-based Engineering and Enterprise
- Big Data
- Internet-of-Things and Industry 4.0
- Digital Twin and Digital Thread
- Cognitive Engineering

Innovation is a key differentiator. To address these challenges, an open and extensible systems engineering development platform with integrated modeling and simulation tools that helps manage the processes and data, provides decision-making support and allows for collaboration is needed. This platform-based approach needs to leverage a common systems engineering and product data model (Model-Centric Systems Engineering) that encompasses well written requirements, platform, program, project, system definition, product structure, lifecycle and configuration-management capabilities. Essentially, such an innovation platform is a key enabler to reach higher systems modeling maturity levels and in turn, help a company reach a more competitive position within the organization's business model. The various levels of such an approach that need to be enabled and supported by an underlying in a platform technology are shown in Figure 1.

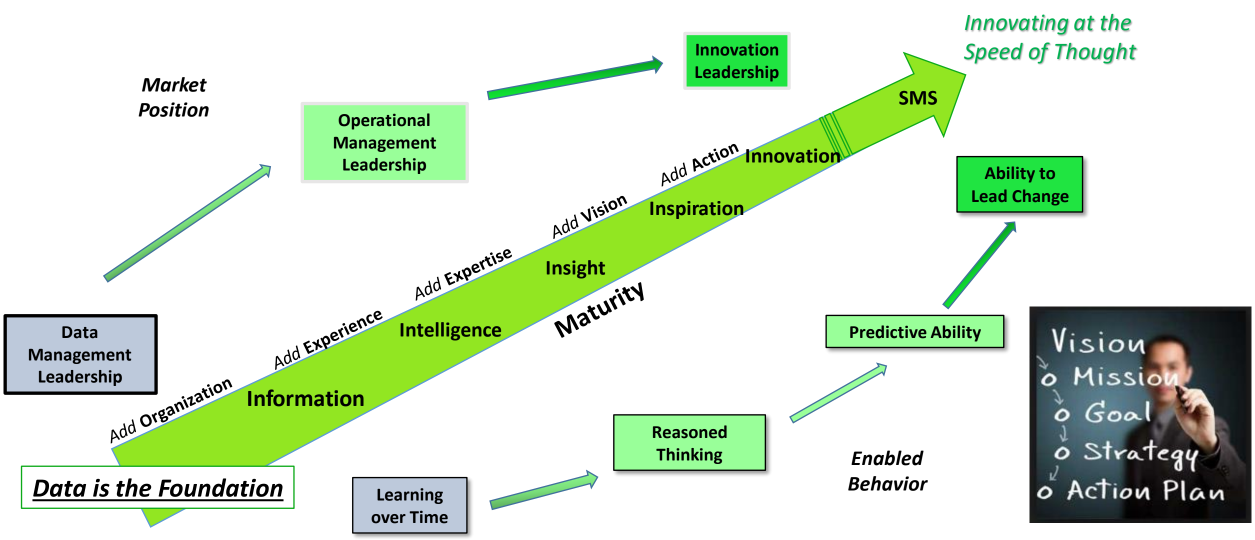

Figure 1: Innovating at the Speed of Thought

The unified data model needs to support cross-discipline decomposition and aggregation, at the same time maintaining the links, relationships and rich semantics that exist between the individual artifacts that describe the system or product throughout the entire life-cycle of a product or process. (Figure 2)

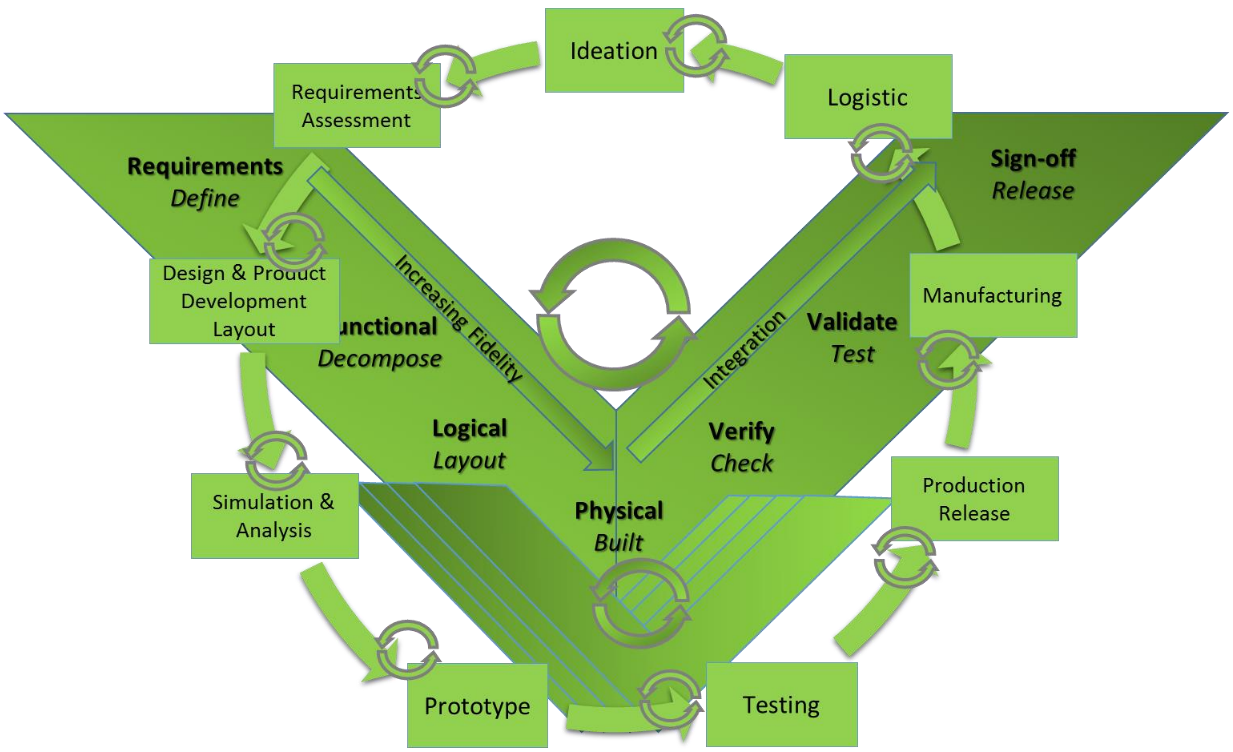

Figure 2: SMS is an Iterative Process Throughout the Product Life Cycle

Systems Engineering and its related benefits are best described by the traditional 'V' model as shown in the adopted by SMS_ThinkTank™ Figure 2. Implementing a successful systems engineering practice is a complex task, much more complicated than just following the predicted fields of the "V", and must be embraced as it relates not only to the corporation's processes and product feasibility, but to the organization and technologies as well. Systems Modeling and Simulation (SMS) is now widely recognized as a core element of the "digital thread" that must be connected to enable and influence key product development decisions and activities throughout the future "model-based enterprise". The SMS framework can be described through the following categories and how they are connected and enabled:

- Organization / Culture / People
- Process
- Technology

A proper deployment of the systems engineering thinking under the terms of SMS in all those above-mentioned categories must also include foundational categories such as:

- Enabling infrastructure
- Data and knowledge exchange

Companies have discovered and reported that too many times, projects overrun expectations or fail completely due to the lack of properly defined requirements. Robust downstream tools are only capable of quickly automating errors if the initial data is sparse, incorrect, poorly defined, poorly managed or even non-existent. 80% of main engineering decisions are taken in the first 10% of project lifecycle (Figure 3).[1]

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[1] Building A Business Case for Systems Engineering: the 2012 SE Effectiveness Study © 2012 Carnegie Mellon University, 22-Oct-2012, Joseph P. Elm, Software Engineering, Alan R, Brown, Boeing Company

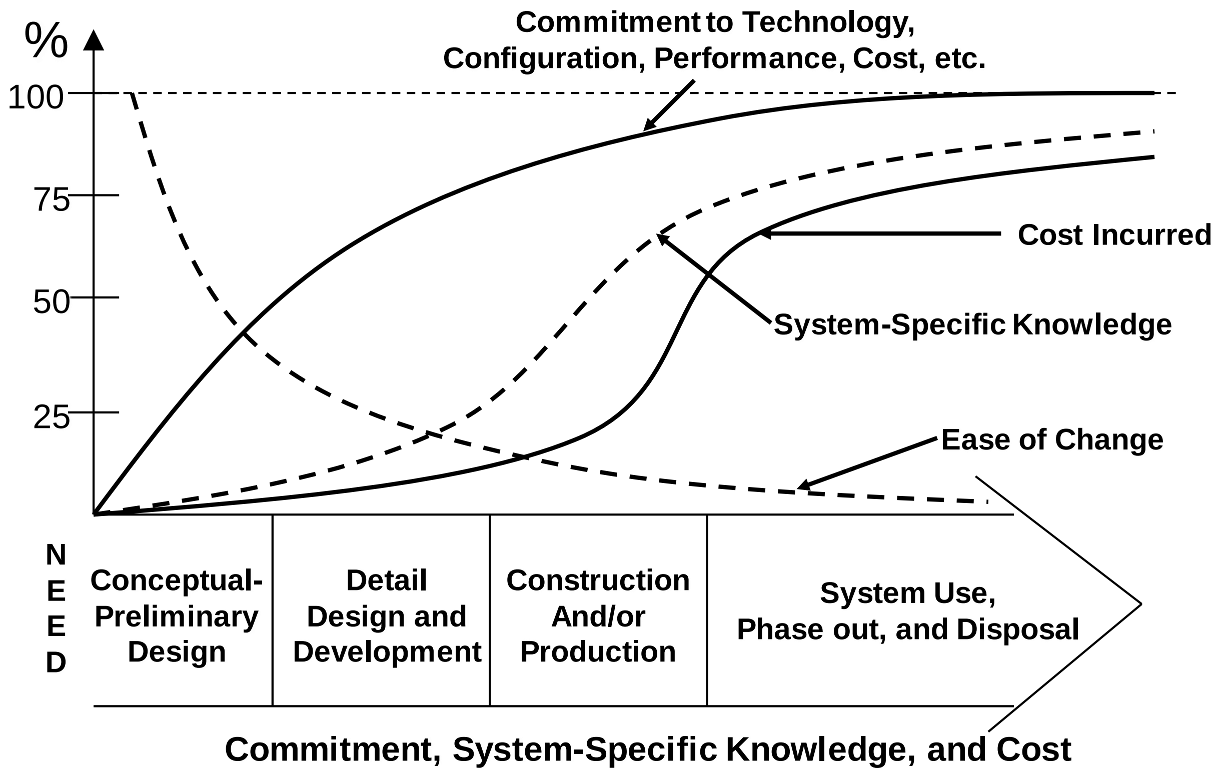

Figure 3: Time-Phased Sensitivity of SE to Total System Life Cycle Cost

Furthermore, up to 50% of projects are behind schedule due to poor early systems architecture validation; and more than 40% project failures due to lack in requirements management and traceability.[2]

It's difficult to justify the benefits of systems engineering in terms that program managers and corporate managers can relate since these benefits are less obvious such as cost avoidance (e.g., reduction of rework from interface mismatches); risk avoidance (e.g., early risk identification and mitigation); improved efficiency (e.g., clearer organizational boundaries and interfaces); and better products (e.g., better understanding and satisfaction of stakeholder needs). [1]

However, with this said, studies have been performed primarily sponsored by INCOSE (International Council on Systems Engineering) and universities to quantify many of the benefits associated with the proper implementation of systems engineering. By employing systems engineering within projects, companies have realized schedule reductions by more than 20% and cost savings exceeding 20%.[1]

In a recent study, programs deploying the least amount of systems engineering had only 15% of the highest level of program performance. Among those deploying the greatest amount of systems engineering, 56% delivered the highest amount of program performance. For the most challenging programs, the number of programs delivering high program performance increased from 8% to 62% with increased systems engineering deployment (Figure 4). [1]

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[2] INCOSE VDC Analysis; INCOSE Systems Engineering Center of Excellence, Honourcode Inc., "Overrun Schedule and Cost"

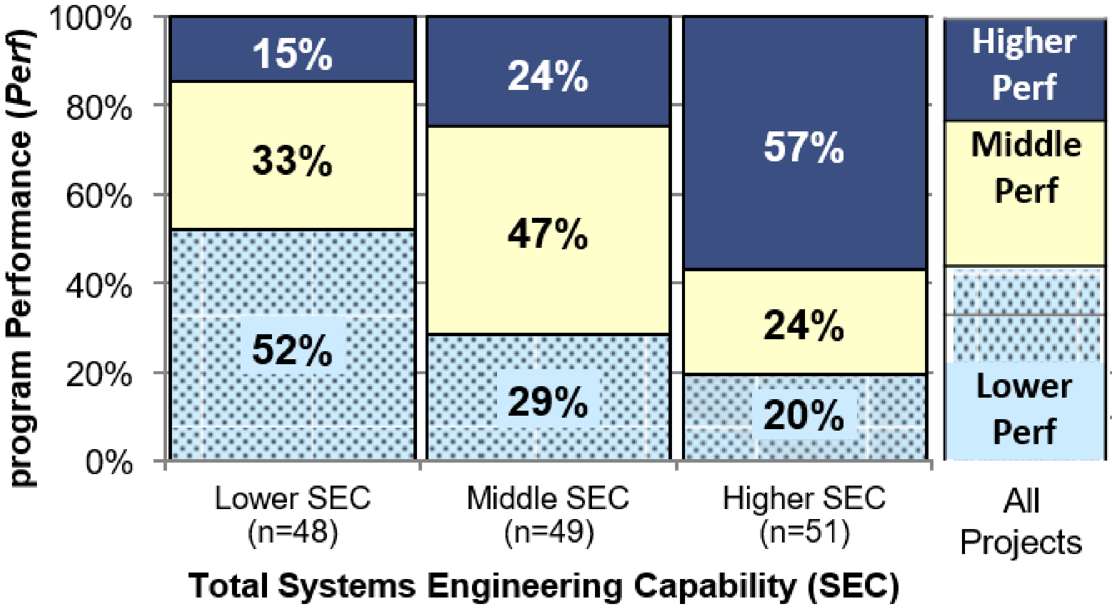

Figure 4: The SE Effectiveness Study - 2012

In addition to the hard metrics, consider a scenario where a full product had to be built and tested to identify functional failures. This begs the question why these expensive tests were not done in a lesser risk virtual environment incorporating common standards and platforms and utilizing HiL (Hardware in the Loop), SiL (Software in the Loop) and MiL (Model in the Loop) practices to identify serious gaps earlier in the development cycle. Another scenario is even more startling when a product is shipped to the field and functional failures are realized between the mechanical, electrical and software systems. Could this have been prevented by the clear and concise identification of stakeholder needs through a good systems engineering requirements process, and/or by developing the product using a platform-based approach leveraging a common systems engineering and product data model? We must also ask ourselves these questions: Are we constantly putting out fires? Why? And one of my favorite old adages, "If we don't have time to do it right the first time, how do we find the time to do it over?"

Implementing new approaches is challenging. Developing a Model-Centric Systems Engineering environment means the creation of digital threads within and across the different domains and disciplines involved for the specific design objectives. Simply creating vast amounts of digital data does not guarantee program success. A strong foundational governance around the virtual product development process that defines best practices for modeling and simulation and its related / linked disciplines, along with physical test in combination with system verification and validation, is essential. It must be combined with a simulation data-management system inside the platform to enable proper capturing and reuse of data, knowledge sharing across disciplines and throughout the enterprise and making the proper data available to all the stakeholders involved in the lifecycle of a product.

This is where a solid understanding is required for:

- Product system
- Ecosystem
- Solution system.

The modern reality demands that we make use of the newly created and stored data real-time. We cannot just use the data anymore to provide business analytics to develop up-front business scenarios, but we need to be able to run scenarios real time to make immediate decisions based on the situation in the field and operating environment. This real-time collaboration around a visual, model-based design environment will be the catalyst to affect a cultural transformation that achieves the Model-Centric Engineering vision. However, this cultural change cannot be successful without management support at all levels, most importantly at the highest level. Change can be uncomfortable and may be resisted by many stakeholders in the process.

In summary:

Again, innovation is a key differentiator. Companies define their market position by the way they capture, work with and deploy data as a major key asset and what cultural behavior they demonstrate in their day-to-day operation. Innovation leaders realize that accurate and accessible data is the foundation for insight and inspiration. They make use of data and derive knowledge from this data in real-time (or close to it). This is what we call "Innovating at the Speed of Thought". (Figure 1)

Therefore, System Modeling and Simulation is not just about product and process, it is also bringing the surrounding ecosystem with its culture and behavior into play and linking these critical elements together. This combined structure is foundational to approach and achieve sustainable innovation and be disruptive.