The case for

Simulation Lifecycle Management

Report 1 of 3:

SLM whitepaper

Prepared by SIMULIA, a Dassault Systèmes Brand

How companies spend millions on simulation but fail to capture, manage, and reuse the resulting intellectual property

The use of engineering and scientific simulation techniques to understand and predict the real world behavior of physical phenomena is widespread across a number of diverse industries. This is true for simulations involving product performance attributes, manufacturing processes, or fundamental research. The benefits that result from the use of simulation are around us every day, from the vehicles we travel in, to products we use every day in work or play, to medical devices that provide treatments seemingly impossible only a few years ago. These techniques, when used effectively, provide a distinct business advantage to product manufacturers if they replace or augment costly, time-consuming physical prototyping and testing.

Best-in-class companies use simulation techniques earlier, more often, and more effectively

While simulation technology is constantly evolving to meet the demands of designers and engineers, there remains a wide disparity in the effectiveness of simulations to impact product/process design decisions. This disparity exists at multiple levels: across industry segments, across companies within an industry segment, across simulation disciplines (structural, fluid, chemical, etc.) within a company, and even across individual methodologies within a simulation discipline. The quest to markedly improve the efficiency and effectiveness of simulation remains a challenging but fundamental goal for many companies.

The quantitative analysis by the Aberdeen Group in their October 2006 publication, Simulation-Driven Design Benchmark Report, suggests that best-in-class companies use simulation techniques earlier, more often, and more effectively than the laggards in their respective industry segments. Interestingly, it is these best-in-class companies, not the laggards, that are the most vocal in driving for new solutions that will make the use of simulation an even more effective and integral part of their overall business process.

The efficiency and effectiveness of simulation within a workgroup or enterprise is driven by several factors, including:

1. Competency of the simulation technology and the people utilizing it
2. Integration, adoption, and acceptance of simulation within standard business processes
3. Capture, management, and reuse of the intellectual property resulting from simulation

Valuable intellectual property is generated during the design, deployment, and execution of simulation methods

There is much to debate concerning the first point, in particular the disconnect between those who believe (wrongly in our opinion) that simulation is converging toward commodity status and those who propose (as we do) that continuous evolution of simulation technology, methods, usability, and performance will be a key differentiator for the foreseeable future.

However, this document is concerned primarily with the second and third points, which focus not on the sophistication or competency of the technology, methods, or human resources involved, but on maximizing the business advantages associated with a given simulation capability within an organization.

The most successful product development companies will, in our opinion, place equal emphasis on all three factors above. Our belief is that those who fully embrace these principals will enjoy disproportionate benefits over those who focus instead on just one or two components of this holistic philosophy.

Valuable intellectual property (IP) is generated during the design, deployment, and execution of simulation methods, along with significant associated costs in the form of software, hardware, and human resource expenditure. It is only recently, however, that some enlightened organizations have begun to focus on managing these assets and costs in a way that systematically optimizes the potential return on investment.

We have significant experience in situations where control and management of simulation IP has been largely ignored with significant negative consequences to effectiveness, efficiency, and business benefit.

Typical instances include:

- **Lost Data** *(such as material properties or results)*
  Problem: Simulation data is lost or confused with similar results
  Symptom: Wrong decisions are made or simulations are repeated with significant resulting cost and time delay

- **Non-Standard Methods** *(such as modeling technique or software chosen)*
  Problem: Individuals design and execute their own preferred methods
  Symptom: Results have questionable absolute value, lack repeatability, and cannot be reused reliably

- **Communication Problems** *(between people, disciplines, or companies)*
  Problem: No framework or language for passing information or collaborating in a simulation context
  Symptom: Inefficient and error-prone decision making

Our contention, however, is that the data, processes, and knowledge captured within simulation and simulation methods provide a significant competitive advantage–especially in situations where simulation competency is high but process competency is yet to be formulated and captured. To capitalize on this advantage and make direct impact on enterprise growth and profitability, simulation assets must be effectively deployed, adopted, retained, protected, and reused.

Product Lifecycle Management (PLM) systems have evolved rapidly in recent years and now provide collaborative Virtual Product Lifecycle Management of complex product, process, and resource information–from marketing and design to manufacturing and maintenance.

> *"Simulation Lifecycle Management will allow for many, previously excluded, downstream elements of projects to be engaged with the upstream elements as early as the concept creation stage. This early integration of experts, designers, and managers, with requirements is the key. It will improve the productivity of the entire technical community to innovate...innovating how we innovate"*
>
> **Tom Lange, Director, Corporate R&D Modeling and Simulation, Procter & Gamble**

In fact, PLM provides much of the infrastructure and functionality required to make a significant contribution to the goals we have laid out with respect to simulation, but only if the unique elements of the data and processes associated with simulation are carefully taken into account. The requirements of simulation technology, methods, data, and processes are in many ways more demanding than those associated with PLM, including:

- **Data Model**
  The richness, granularity and context of simulation data is distinct and specific, traversing multiple physical domains (multiphysics) and solution procedures (linear, nonlinear, static, dynamic, transient, etc.)

- **Performance**
  Simulation data can be orders of magnitude larger than product structure related data and depend on high-performance, multi-processor computing resources for meeting performance requirements

- **Context**
  To be of archival value, simulation results must be associated with the product being simulated, the functional requirements, the methods used, the environmental conditions, and stimuli considered, etc.

We refer to the emerging space focused on improving simulation effectiveness within PLM and scientific environments as Simulation Lifecycle Management (SLM).

In the next report in this series, we describe the critical elements that we believe SLM must provide in order to deliver significant operational and business benefits to adopting organizations and enterprises.

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Report 2 of 3:

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Critical elements of a Simulation Lifecycle Management Solution for enterprise deployment

The management of the intellectual property associated with simulation tools, data, and processes is collectively referred to as Simulation Lifecycle Management (SLM) (see Report 1 in this series). SLM can intrinsically be an integral component of Product Lifecycle Management but due to the unique traits of simulation that differentiate it from how products or processes are managed in PLM, SLM requires specific considerations.

Historically, the disconnected and isolated nature of simulation work has resulted in tremendous inefficiencies as valuable knowledge is retained solely in the minds of the analysts. Collection and dissemination of information has been largely through manually prepared reports, which are inherently inappropriate as a mode of managing critical information such as the relationship of simulation to product or process development. The relationship between simulation data and product design or process development data is shown in Figure 2.1.

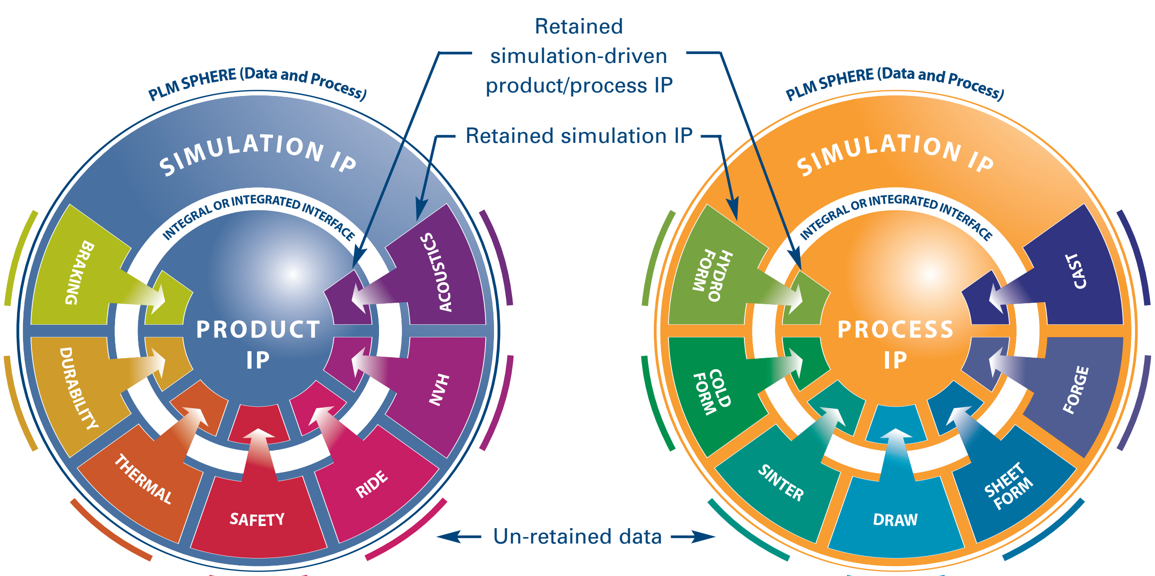

Figure 2.1: Relationship of Simulation Lifecycle Management to Product/Process Lifecycle Management

One class of simulation is intended to support product design decisions, while another class is intended to support process development decisions (e.g., manufacturing process simulations such as forging or blow molding). Depending on the nature of their business, most companies perform both classes of simulation; however, some focus primarily on either one class or the other. In each class, it is useful to segregate, but tightly associate, the simulation data from the product or process data.

We view simulation data as being divided into three main categories:

1. Data Directly Supporting Product/Process IP

The principle objective of most simulation is to support decisions about product design or process development. In most cases the product or process under consideration has a set of functional performance requirements that are translated into engineering targets. The purpose of the simulation is to accelerate the company's confidence and contribute to its intellectual capital in a product or process design such that it satisfies the engineering targets. This intellectual capital is characterized and captured in the performance attributes of the proposed product/process design. SLM, within the context of PLM, is the optimal vehicle to manage the performance attributes of a product or process as predicted by simulation techniques, or possibly even by physical testing. This data should be closely associated and linked to the product or process it supports.

2. Data Supporting Simulation IP

Simulation data has intrinsic value to the company—and the development and capture of best-in-class simulation techniques is essential to expanding its use and impact. Best practices, or standard operating procedures, that govern successful, reliable, repeatable methods for performing multiple types of simulation must be retained as valuable company assets. Retaining best practices enables reuse of the methods so that they may be leveraged, improved, and optimized in the future.

3. Unretained Data

Some simulation data is not retained at all. Either this data is relevant only during the execution of the simulation and can be discarded shortly after completion, or the data sets are too large to manage using conventional approaches. In the latter case, which is very common, sufficient simulation data is extracted and retained such that any discarded information can be reproduced at a later time if needed.

Practical Business Example

A tire design could have a marketing requirement to meet a minimum Treadwear Grade of 400. The Engineering Department translates this marketing requirement into engineering targets, such as a maximum frictional energy dissipation rate, which must not exceed a certain value under a set of predefined load cases based on company standard operating procedures.

> Simulation and Product IP: Simulations are used to predict and capture this performance attribute (frictional energy dissipation rate), and the results subsequently are used to make decisions that influence and validate the tire design. This simulation-driven product information should be retained and tightly associated with other product data on this particular tire design.

> Simulation and Process IP: To maximize abrasion resistance and minimize crack propagation in the company's vulcanized rubber compounds, the Materials Department performs simulations to determine mixing and curing techniques and to refine inspection processes that test the properties of the resulting material. The company should retain this simulation-driven process information and associate it with other information about the mixing, curing, and inspection processes, which affects multiple tire designs.

Both sets of data contribute to the goal of achieving the Treadwear Grade marketing requirement for this particular tire design. However, one set can be characterized as program data (relating directly to this particular tire design), and the other as non-program data (contributing to multiple tire designs). In addition to this managed product or process information, the company should also retain the knowledge associated with the successful performance of these simulations as valuable IP. Data that is generated to complete the simulation work but has no intrinsic value is discarded.

Building a reliable SLM system

The degree of integration across the simulation and product/process worlds will vary with organizational type and structure and is driven by a number of factors, but there are several critical principles that need to be followed to achieve the full benefits SLM can deliver.

At its core, an SLM solution must have been designed from the outset to possess the appropriate architecture to satisfy the integration, deployment, and maintenance demands of a broad and constantly changing set of information technology (IT) environments. IT-related solution aspects such as this will be addressed in future reports, but here we describe four functional elements that an effective solution must provide [see Figure 2.2]:

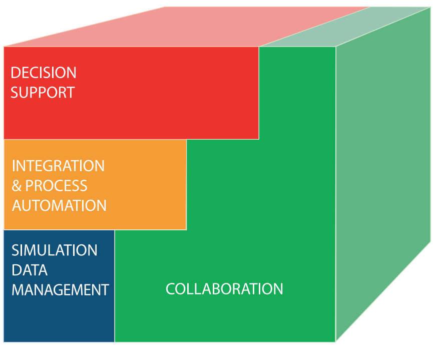

Figure 2.2: Four Functional Elements of SLM

- **Collaboration**
- **Simulation Data Management**
- **Integration and Process Automation**
- **Decision Support**

It is our experience that apart from the ability to collaborate, which is required at all stages, each of the other components are a necessary precursor to the next. There is no quick-fix solution, rather a systematic set of steps that, if followed correctly, will bring value from the outset and lead an organization through an evolution that will allow simulation to achieve its full engineering and business impact. We outline these solution elements below.

Collaboration

No product or process is created in isolation, and simulation should be equipped to fulfill its role as part of the team. Typically, simulation will impact a wide spectrum of product and process design functions and should be accessible to each. Furthermore, the design changes suggested by the simulation results of one individual or team can often be at odds with the direction suggested by other individuals or teams, whether they are simulation related or not.

The best design requires simultaneous treatment and awareness of the impact of proposed changes by multiple areas of functional responsibility, as illustrated by the cell phone design scenario depicted in Table 2.1. Time-to-market will be a direct function of the efficiency with which a design team reconciles any conflicting constraints. Therefore, an essential element of SLM is to foster cross-functional collaboration as a means of enabling innovation and instilling quality into product and process design under tight time constraints. There are enormous benefits associated with sharing and co-locating design data and simulation data from multiple disciplines in a central, collaborative work environment—where all parties can have insight into the latest intellectual property and can monitor the progress of colleagues associated with specific projects.

Furthermore, the SLM environment must be easily navigable by a diverse set of users that need the data to perform their job responsibilities. Three-dimensional visual representations of the data provide an intuitive way for all parties to quickly find and understand simulation data and results.

Table 2.1: Impact of Cross-Functional Simulations on Cell Phone Design Decisions

Mechanical Simulation	Consumer taste has driven cell phone designs toward smaller and lighter models. Yet consumer expectations on wear, strength, and durability continue to rise. Cell phone manufacturers regularly incorporate virtual drop and vibration testing, using technology that is proximal to that used in automotive crashworthiness and NVH, into their design process.
Thermal Simulation	The cell phone is no longer just a phone. The devices now regularly perform as cameras, music and video players, and personal digital assistants. In addition, the devices are expected to work reliably in extreme environmental conditions for long periods between battery charging. As a result, the ability of these devices to manage and channel thermal energy plays a significant role in their design. Thermal simulations play a critical role in influencing the design of the phone casing and electronics placement.
Electromagnetic Radiation Simulations	The cell phone must emit radiofrequency energy at levels high enough to reach antenna towers kilometers away. This objective must be balanced with regulations regarding the potential health risks associated with absorption of this energy by the human head. The design of a cell phone casing, electronics, and antenna construction influences widely different near and far-field radio frequency energy signatures around the phone. Electromagnetic radiation simulation is regularly employed in cell phone design to balance functionality with safety.

Simulation Data Management

The effective management of paper drawings was addressed by the print room. The effective management of CAD models was addressed by PDM systems as a critical precursor to complete PLM processes. The effective management of simulation data is an essential, fundamental foundation of SLM. Seasoned simulation practitioners, who for years have resisted the use of commercial systems to help manage their data, are now beginning to realize that the functional maturity of simulation has put them directly into the critical path of their businesses, and they are embracing the vision of SLM.

IT departments, who have struggled to provide the data management tools necessary to make simulation more effective for their business as a whole, are now eager (or shall we say compelled) to bring their wealth of experience into this new domain. What is missing are products that unite a deep understanding of the demands of simulation, its role in the enterprise, and the knowledge to determine which data and processes belong under formal management and which data and processes should remain ad hoc.

The motivations for managing simulation data include:

- **Traceability and Audit Trail**
  Enable quick access to "Who did what, when, how, and why?"
- **Book Shelving**
  Place company best practices regarding simulations in a searchable, managed system to foster high quality, reusable, repeatable work.
- **Control and Continuous Improvement**
  Control data, processes, simulation methods, and software applications released to the company to maintain quality and consistency and to provide a vehicle for continuous improvement.
- **Backup and Archival**
  Retain Simulation IP in a safe, secure, professionally managed IT environment.
- **Collaboration**
  Foster innovation and provide relevant data to cross-functional teams that need it. Ensure that key stakeholders can track progress and access the data quickly so that the teams can meet their schedule responsibilities.
- **Process Automation**
  Automate critical processes to minimize cycle time and broaden the population of simulation users. A process can be automated successfully only if the data used in the process is under formal management and if the process has reached an acceptable level of maturity.

Candidate categories of simulation data for management by SLM are listed in Table 2.2. Not surprisingly, many of the key collaboration and lifecycle management tools available in PLM systems can be readily extended to suit the demands of an SLM system. Table 2.3 is a partial list of the capabilities that PLM services bring to simulation data to control not only location, but also security, retrieval, and entire lifecycle functions.

Table 2.2: Candidate Simulation Objects for Management in SLM

SLM Object	Description
Simulation	A collector for all metadata, links, content, and tasks associated with a simulation. Contains or references the following organizational categories: • **Product/Process** Reference to the Product or Process being simulated • **Context** The product or process in the context of the simulation being performed (for example, surrounding environment and stimuli) • **Results** Result files or abstractions (plots, reports, animation files, etc.) • **Specifications** Instructions and guidelines for executing this simulation
Simulation Product Structure	The design product structure transformed into a set of hierarchical simulation product structures that include geometry, simulation representations (meshes, rigid bodies, matrices, substructures, etc.), connections, positional data, section properties, and non-geometric data.
Simulation Applications	Simulation software applications released to the enterprise in a controlled manner.
Simulation Application Connectors	Simulation and application-specific instructions and executables for exporting data from SLM to compute servers for execution with managed Simulation Applications, execution monitoring, and import of relevant data back to SLM control.
Engineering Targets and Performance Attributes	Requirements for the product or process translated into managed engineering targets. The corresponding managed performance attributes of the proposed product/process design as predicted by simulation (and possibly by physical testing).
Simulation Method	Collections of pre-configured simulation data and processes for formal deployment to the enterprise as company approved Standard Operating Procedures.
Workflow	Managed electronic simulation process workflow.
Other	Simulation data that may reference other PLM objects such as Documents, Parts, Products, etc.

Table 2.3: PLM Capabilities Leveraged by SLM

Service	Description
Persistence	Retained in a relational database.
Navigation	Organized and represented in a manner that facilitates efficient exploration over object instances and associated data. Optimally, the objects will have 3D contextual representations to make them more readily recognizable.
Attribution	Tagged with descriptive attributes that enable efficient search and query to facilitate both improved productivity and data reuse.
Configuration Management	Enabled with version control and governed by change and configuration management principles as desired.
CRUD editors	Editors to allow creating, reading (viewing), updating, and deleting objects. Copy and paste capabilities are also provided with the PLM objects.
Security	Governed by access control principles such as lock/unlock, transfer ownership, and accessibility, based on numerous factors and variables.
Lifecycle Management	Maturity states that dictate certain business logic as the objects progress through their lifecycles and fully traceable historical data are captured and retained.
Impact	Relationship linkages with other PLM objects that provide relevant behaviors such as indicating that a recent design change has occurred that may impact or invalidate previously generated simulation results.
Content	Stores or links to content such as data files.

Integration and Process Automation

While there is evidence of consolidation in the simulation software industry (such as the 2005 acquisition of ABAQUS, Inc. by Dassault Systèmes), companies typically adopt a best-in-class approach including internally developed simulation software applications that leverage proprietary technology or internal IP. In most instances, third-party specialist providers deliver specific advantages over more general solutions. This leads to a proliferation of simulation applications within a company and even further within the extended enterprises of most major manufacturers. Over time, simulation has grown more critical to the business mainstream, and organizations face the growing challenges of using such unconnected applications efficiently in the absence of SLM.

To address these challenges, companies must begin to enforce some discipline on the mechanisms used to access and manage these applications. Vendors must be called upon to create application connectors that readily integrate applications, data, and governing processes into SLM services. To be effective over time, an SLM system must provide the appropriate support services to a wide variety of simulation applications without compromising fidelity. Customers must be able to plug their internal applications into the unified environment with minimal effort and cost to maintain.

After simulation data is under management and application software is integrated into the environment, companies can then begin to automate proven simulation processes. Automated workflow and process templates provide a consistent means of delivering data to people, teams, and systems. There are three main levels of process automation in which simulation plays a role:

1. Simulation tasks and activities can be integrated into higher level business processes such as the New Product Development (NPD) process or the Engineering Change Management (ECM) process to deliver simulation tasks and associated data to analysts, engineers, designers, and managers.

2. Low-level simulation tasks executed by people and/or applications (via application connectors) can be automated and chained together with, for example, the output of one task serving as the input for another.

3. Chained simulation tasks can also utilize Design of Experiments (DOE) or Multi-Disciplinary Optimization (MDO) algorithms to construct and evaluate design spaces versus simple evaluation of design points.

DOE and MDO have emerged as important activities for mature simulation processes. For example, companies in the consumer packaged goods industry are motivated to perform as many simulations as possible in the time available so that product development can deliver a highly optimized product. A small cost savings per product results in additional, significant profit when factored by the millions of units produced.

Lastly, demonstrating good correlation with physical test results supports confidence in simulation techniques, especially when developing new methods or adopting innovative materials. SLM is able to link the worlds of physical and virtual testing by integrating or tracking test results within the SLM system and providing statistical correlation capabilities.

Decision Support

Well-engineered products and processes originate from a set of functional (as well as physical and logical) requirements. These requirements identify the way in which the product or process delivers its value to the market. The purpose of virtual testing (simulation) is, first and foremost, to contribute to a product or process design by delivering performance attributes that satisfy functional requirements.

Companies can perform virtual testing faster and cheaper than physical testing. Beyond this, simulations provide insight that cannot be achieved by physical testing and contribute to design optimization by ensuring that functional requirements are satisfied while optimizing other factors such as cost, weight, durability, or process cycle time. The underlying motivation for each of the solution elements discussed above (collaboration, simulation data management, integration, and process automation) is to provide support for design decisions.

Therefore, SLM solutions must provide capabilities that manage two important topics:

1. **Engineering Targets**

   While it is true that some very good product and/or process designs are sometimes stumbled upon, these are exceptional events, not the rule. Most successful companies incorporate "design to target" or "design intent" principles in their development processes. A functional requirement is established that must be satisfied for a design to be acceptable. Once achieved, the design can then be optimized. PLM systems provide very good solutions for managing and tracing requirements. These solutions can be leveraged and extended by SLM to further develop abstract functional requirements that then positively influence engineering targets.

For example, the functional requirement for the tire example cited in this report is a Treadwear Grade that exceeds 400. However, the engineering department translates this functional requirement into a set of maximum frictional energy dissipation rates that must not be exceeded when the design is subjected to a set of load cases. An SLM solution should provide capabilities to manage these engineering targets and associate them with products, processes, simulations, and performance attributes.

2. Performance Attributes

A performance attribute is a record of a given design's ability to achieve an engineering target, as predicted by simulation, physical testing, or legacy know-how. Often, multiple simulations, such as the set of tire load cases mentioned above, are performed to determine if a proposed design satisfies an engineering target or a set of engineering targets. An SLM solution should provide capabilities to manage these performance attributes and associate them with products, processes, simulations, and engineering targets.

Decision support is the process by which engineering targets, performance attributes, and supporting evidence are projected to individuals who are responsible for making key product or process design decisions. Speed and visibility are critical elements of decision support in the context of the overall SLM vision. Today, decision support tools that effectively project simulation results to decision makers are largely immature and not integrated from a business process perspective.

Innovative industry and customer-specific methods for presenting simulation results and IP will generate real competitive advantages, and SLM solutions should provide a framework for this innovation. Table 2.4 lists just a few ways in which simulation and test results can be organized and projected to decision makers for maximum value.

Table 2.4: Decision Support Capabilities Applied to Virtual and Physical Test Results

Decision Support Mode	Description
Trend Analysis	Certain classes of simulation produce discrete results. Others provide information on trends. In the latter case, reporting and visualization tools are necessary to collect and present the trend data in a concise form.
Enveloping	Simulations are often performed over a range of scenarios, such as analyzing the stresses and deflections on a wing flap every 5 degree increment over its full range of positioning. Methods for presenting the collection of results within the envelope of study are beneficial to decision makers.
Hierarchical Dashboards	Simulations are often performed to determine performance attributes at each of the component, assembly, sub-system, and total-system levels. Dashboards that roll up the performance attributes at each level of the hierarchy and compare them to their associated engineering targets are beneficial to decision makers.
Differencing	Tools enabling side-by-side comparisons of simulations and simulation results are needed.
Statistical Test Correlation	Confidence levels in simulation results are boosted by correlation with test results. Stochastic correlation methods provide measured confidence levels.
Trade-off Analysis	Tools that capture and project the influence of a design change across a wide spectrum of disciplines are beneficial to decision makers.

In the next part of this report we will outline the process of implementing an SLM system to gain or maintain competitive advantage.

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Report 3 of 3:

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Essential steps in successful, early deployment of SLM to establish and maintain competitive advantage

Today, more than ever, companies are faced with developing the best products at the lowest cost and in the least amount of time in an increasingly competitive environment. World-class companies have recognized that effective utilization of simulation as a design tool or as a replacement for physical prototypes and testing can provide them with a key edge in the coming years. The vision of SLM is to capture the simulation capabilities and processes of an organization and build them into a complete lifecycle environment that aggregates the IP associated with these simulations and makes it available where it is needed in a form that can be utilized easily.

> The goal of SIMULIA is to deliver the first economically deployable SLM solution to the market

The management of the intellectual property associated with simulation tools, data, and processes, collectively referred to as SLM (see Report 1 in this series), can be seen as an integral component of Product Lifecycle Management but requires special treatment because of several traits that differentiate it from how products or processes are managed in PLM (see Report 2 in this series).

Implementation of the solution elements described in earlier parts of this document must be achievable across a wide spectrum of industry, scientific, and simulation domains. Furthermore, companies are no longer willing or able to fund an army of consultants with an open-ended budget, scope, and deployment schedule.

As has been proven with PLM, a phased, incremental approach to SLM implementation is the most effective as it allows an organization to integrate capabilities into their environments in manageable amounts, building to a complete set of tools that lead to dramatic process improvements. However, even in the early phases, it is important that the choice of solution platform is truly scalable in terms of functionality and performance. Many times the scope is limited at the outset and the choice of solution does not consider the long-term goals adequately. While this may seem obvious to large, complex, distributed enterprises, the data and computing demands of a smaller organization or workgroup will grow tremendously as the efficiency gains from SLM begin to emerge.

Choosing the right solution

Considering these important factors, a key to success for both enterprise and workgroup scenarios will, therefore, be the provision of a set of robust "out-of-the-box" capabilities within the SLM product portfolio, including a wide range of configuration options such as drag-and-drop workflow templates, methods to capture data and processes, and support for powerful scripting. When customization is sought to further maximize a company's intellectual property to achieve a competitive advantage, the product must possess robust customization techniques.

Organizations intending to deploy SLM solutions should be wary of proposals where customization of base functionality is required before end user deployment and value realization is possible. We propose that companies should evaluate the relative proportions of "out-of-the-box" to "configuration" to "customization" capabilities shown in Figure 3.1. Such an evaluation will correlate closely to the time and effort taken to deploy SLM for real-world usage leading to early cost and time savings.

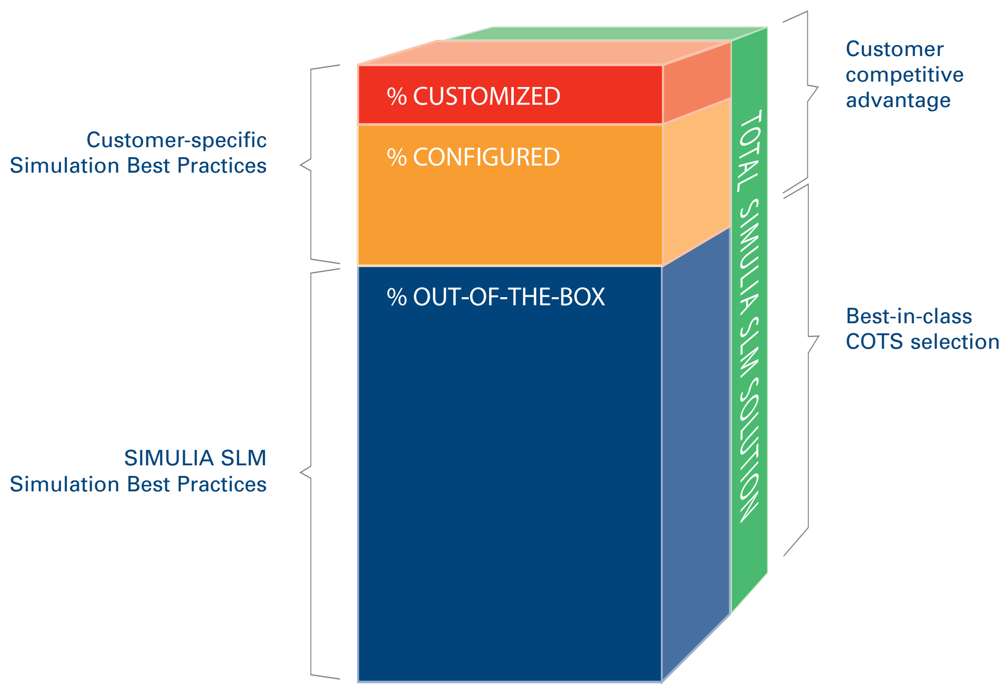

Figure 3.1 SLM: Out of the Box; Configurable; Customizable

A fully realized SLM system will be a journey, not a single event. We believe there will be considerable investment from solution providers and a need for constant innovation in years to come to achieve the complete vision outlined in this report.

Dassault Systèmes is the market leader in PLM and has for many years provided collaborative solutions for product, process, and resource management to enterprise customers involved in the most demanding distributed product development environments. With the acquisition of ABAQUS, Inc. and the establishment of the SIMULIA brand, DS has created a unique combination of both PLM and simulation technology know-how and a customer base and partner ecosystem that is unmatched.

- **PLM Expertise**
  We firmly believe that PLM provides a strong foundation upon which to build SLM solutions–in many companies where PLM is successfully deployed, SLM should be an integral and seamless component of PLM. However, we recognize that the unique aspects of simulation data and processes require special treatment. The degree of integration between the PLM space and the SLM space is an important decision that must be made on a case-by-case basis. A robust solution will span the range from a stand-alone SLM deployment to a seamlessly integrated solution.

> Dassault Systemes is the market leader in PLM and has for many years provided collaborative solutions

- **Simulation Expertise**
  Simulation data and simulation processes are unique and must be treated as such. A successful SLM system must keep the needs of the simulation community at the forefront of its design.

- **Product and Process Development Expertise**
  Until now, simulation has been somewhat isolated on remote "islands" outside mainstream product or process development. The time has come to meld simulation into the overall development process so that the true value-generation potential of simulation can be fully realized. This requires innovative methods to provide a wider audience with predictive and insightful simulation capabilities to be used as an integral part of the overall design process and a driver for accelerating innovation.

- **Information Technology Expertise**

  The people, processes, and technology associated with a successful deployment and adoption of SLM are not addressed in detail in this document, but are nevertheless crucial to success. For simulation to have an impact at the enterprise level, information technology professionals will need to play an integral role in the successful execution of an SLM vision. We will address these issues in subsequent reports.

Ultimately, the key element for SLM success will be the strength of conviction held by organizations that see simulation today as an important, yet isolated, component of their operation—and for them to recognize, take control, and leverage the significant IP associated with simulation know-how, process, data, and resulting decisions. The role of an SLM solution is to make this approach to realistic simulation a common and natural occurrence in the overall development process.

The goal of SIMULIA is to deliver the first economically deployable SLM solution to the market that is functionally capable of meeting the specific needs of all users (including simulation experts), and scalable from workgroup to enterprise.

We at Dassault Systèmes are by far the leaders in R&D investment for PLM, SLM, and Simulation technology. We truly believe in the vision of SLM and are fully committed to making it a reality.

> *"Accurate and consistent simulation has to be at the heart of any design and manufacturing development process. In order for simulation to provide more than a partial picture, we need system simulation capabilities as well as the ability to carry over simulation results from one stage to the next. A good example of this is the influence that manufacturing processes have on the functional behavior of the final product. The SIMULIA SLM initiative is the right thing to do to get there in a reliable and consistent fashion."*
>
> **Frank Popielas, Manager, Advanced Engineering, Dana Sealing Products Division**

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About SIMULIA

SIMULIA is the Dassault Systèmes brand that delivers a scalable portfolio of Realistic Simulation solutions including the Abaqus product suite for Unified Finite Element Analysis, multiphysics solutions for insight into challenging engineering problems, and lifecycle management solutions for managing simulation data, processes, and intellectual property. By building on established technology, respected quality, and superior customer service, SIMULIA makes realistic simulation an integral business practice that improves product performance, reduces physical prototypes, and drives innovation. Headquartered in Providence, RI, USA, with R&D centers in Providence and in Suresnes, France, SIMULIA provides sales, services, and support through a global network of over 30 regional offices and distributors.
www.simulia.com

About Dassault Systèmes

As a world leader in 3D and Product Lifecycle Management (PLM) solutions, Dassault Systèmes brings value to more than 100,000 customers in 80 countries. A pioneer in the 3D software market since 1981, Dassault Systèmes develops and markets PLM application software and services that support industrial processes and provide a 3D vision of the entire lifecycle of products from conception to maintenance. The Dassault Systèmes portfolio consists of CATIA for designing the virtual product - SolidWorks for 3D mechanical design - DELMIA for virtual production - SIMULIA for virtual testing and ENOVIA for global collaborative lifecycle management, including ENOVIA VPLM, ENOVIA MatrixOne and ENOVIA SmarTeam. Dassault Systèmes is listed on the Nasdaq (DASTY) and Euronext Paris (#13065, DSY.PA) stock exchanges.
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