Simulation Data & Process Management – Vendor Scorecard

Design/Simulation Council

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CPDA: Collaborative Product Development Associates, LLC

CPDA's Product Lifecycle Management (PLM) research programs target the critical decisions in PLM challenging Design, Engineering, Manufacturing, and Information Technology managers and executives. CPDA's PLM collaborative research programs provide in-depth analysis of strategies, products, issues, processes, technologies, trends, case studies, and surveys for assessing technology, business goals and objectives, and implementation road maps. The four collaborative research programs include:

Design/Simulation Council: The Design/Simulation Council supports a framework employing common terminology to integrate and optimize the diverse and divergent specialist activities currently fragmenting design efforts. CAE must fully integrate with design, up front, to close the chasm between design and analysis. A detailed scorecard on SDM focuses on end users' capabilities, requirements, with regular updated participation from twenty-five leading users from over fifteen different companies. The critical requirements for users need to be clearly identified, prioritized, monitored, and continuously updated. Moreover, a strategic, high level review and scorecard of the offerings by leading vendors in simulation data management (SDM) is also continuously updated.

Design Creation and Validation (DCV): The DCV service identifies and tracks advances in design and design-related technologies with a bottom-up view of engineering requirements spanning the full development cycle from the desktop across the enterprise. The service advises clients on their best approach in the emerging technology of knowledge engineering with templates and rule-based architectures, focusing on delivering the needed tools into the hands of product developers, to capture knowledge, and to formalize its use. The use of direct geometry access and manipulation, data translation technology, XML alternatives, and JT options are also assessed. As product development companies outsource more and more subsystem engineering into their supply chains, the need increases dramatically for improved model content, quality, and leveragability, better subsystem analysis, global collaboration, and validation of the manufacturing process. DCV reports on insights and best practices for horizontal integration of design across all product development domains extending across the supply chain that represents an imperative for many companies.

PLM Integration / Product Definition: The leading implementers of PLM face a major transformation. Over ten years ago, the focus on high level coordination across major functional groupings proved to be sufficient. Today, extraordinarily detailed reconciliations entail deep complexity across all individual domains in development, including manufacturing and downstream functions. The program clarifies and evaluates the new capabilities required, highlights the best, most advanced uses of leading technologies, and provides a link between IT infrastructure and the realization of business value. Sponsors seek guidance for defining an implementation road map, reducing product and process complexity and cost, and harmonizing information and product architectures. The strategic analysis planned for 2009/2010 concentrates on: Requirements Management, Model Driven Development, Generic Product Structure, Tight PDM Integration versus Enterprise PDM, and the PLM Open Landscape.

Product Value Management: The Product Value Management (PVM) program extends the analysis of PLM to specific areas across the full cycle of product development that requires particularly detailed analyses. Two specific functional areas have been prioritized by PVM clients. The highest current priority applies to mechatronics, to capture and relate all relevant requirements to development tasks across three disciplines: mechanical, electrical, and software design. In addition, the PVM effort has consistently concentrated on accelerating decision making and improving reliability for collaborative product development across the supply chain.

Collaborative Product Development Associates was formed by the PLM research team of D.H. Brown Associates, Inc. (DHBA).

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Michel Vrinat, Program Director PLM, CAE in Europe, CPDA

EXECUTIVE SUMMARY

CPDA's third in-depth analysis of simulation data and process management (SDPM) solutions concludes that the leading vendors have made excellent progress. There are now capable solutions to enable the adoption of good practices for SDPM. Established on a sound technical foundation, a large set of functions with different levels of capabilities can serve various levels of product design complexity, simulation work volume, or the available human resources. From simple data file and reports management up to the configuration management of analysis models, users should be planning an appropriate road map for the best implementation.

Despite early agreement on the priority expressed by users to adopt a framework based on SDPM, however, the level of implementation has been disappointing. Adoption of the tools has been slow, with the vendors referencing only a few production sites, which generally have limited experience and deployment.

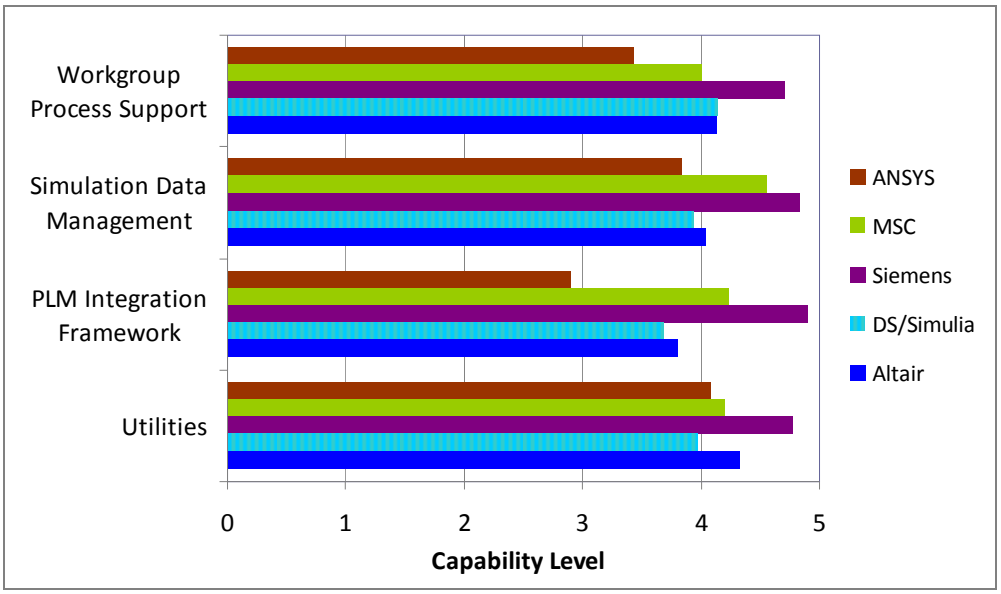

FIGURE A
Vendors' Capabilities

The analysis covered five leading vendors – ANSYS, Dassault Systèmes/SIMULIA, MSC.Software, Siemens PLM Software, and Altair. The vendors demonstrated their solutions in live sessions with intense discussions, except for Altair, whose

new offerings will be delivered in several phases starting at the end of 2009. For this reason, Altair rankings are highlighted separately in the detailed data presented in the full report.

This scorecard is a comprehensive evaluation of features and functions covering sixty criteria in the four main categories summarized in the chart above. These desirable features and functions include leading-edge features, and emphasize process support and integration with other product development tools.

WORKGROUP PROCESS SUPPORT

The simulation engineers, or analysts, represent a highly specialized community too often isolated from other mechanical engineers. The isolation applies even more within large projects that tend to distribute effort between the project team and sub-contractors, requiring significant effort to make sure enough collaboration takes place. The latest SDPM tools may greatly alleviate these challenges. First, they can organize and manage the data, relieving the individual of much non-value-added work. Second, they provide process support so that simulation tasks can be automated. Workflows can be created that not only reduce complexity and required attention to detail; they greatly improve collaboration within workgroups, and communication with other engineering functions.

All vendors have achieved excellent progress in this area over the last two years, with the main differentiation deriving from the change management capability that is best supported by a PLM-based solution. The initiation and propagation of a change request from or to the simulation group is well supported only by two vendors.

SIMULATION DATA MANAGEMENT

Simulation data management (SDM) represents the core of capabilities required for a good design and simulation integration framework. It is also the first step that can be achieved by a company willing to deploy SDPM along a progressive road map. The core of the simulation data management capabilities is very well covered by all vendors, but the link to PLM is still an area meriting additional progress. Also, multi-disciplinary support needs to be further enhanced.

PLM INTEGRATION FRAMEWORK

Looking at the big picture of PLM, starting with requirements management through systems engineering, and proceeding through all phases of product development, the simulation data and processes are still quite isolated. That is reflected in the category's overall ratings, which show several criteria with the lowest average.

Currently, three vendors directly address the integration and management of requirements with simulation data and processes, with the other vendors relying on a simple data exchange through Excel spreadsheets. MSC.Software and Siemens support bi-directional relationships with live links based on APIs or open services support (Open/PDM). DS/SIMULIA supports a direct link from its own requirements management tool and DOORS.

On the other hand, all vendors integrate mechanical design and simulation well, as the most advanced capability in this area. The integration of simulation with physical test activities is also well supported by all vendors. The integration with other CAE COTS, or commercial off-the-shelf, simulation tools is performed through direct data loading from other databases and applications.

UTILITIES

A number of utility functions have been identified that significantly increase the payoff of deploying SDPM solutions by simplifying some tasks and reducing manual work. These involve data exchange functions, specific CAE and PLM COTS integrations, visualization of CAD and CAE models, collaboration functions, and report building including KPIs. Significant progress has been achieved by all vendors on data exchange and other CAE tool integration. The main current weakness relates to the PLM integration, where all vendors have a low rating except for ANSYS and Siemens.

HIGHLIGHTS OF INDIVIDUAL VENDORS

ANSYS

ANSYS EKM (Engineering Knowledge Management) together with Workbench does an excellent job at targeting the analyst workgroup. It is a pragmatic approach. For Workbench users, the extension of scope to EKM should be readily appreciated. Strong emphasis has been put on reusability, making it easy to use and automate for a large number of standard simulation tasks. The integration with other solvers, CAD, and PDM tools is also well covered.

MSC.SOFTWARE

Among all vendors, MSC.Software represents the company that first understood the necessity of managing simulation data and process. MSC has invested heavily in the area ever since. After several years of perseverance in gaining market awareness, MSC can now be proud of the result. Especially considering that MSC.Software is not a general-purpose PLM vendor, its achievement in mastering data and process management is remarkable.

The combination of SimXpert for process support of simulation work and SimManager for data and process management provides a complete and fully operational solution. Moreover, MSC has the largest number of sites using SDPM in production on the market. Large aerospace and automotive companies rely on MSC.Software SDPM tools for supporting a tremendous increase in the volume of simulations to be performed with tangible and measurable benefits.

SIEMENS PLM SOFTWARE

Teamcenter for Simulation, a specialized application on top of Teamcenter Unified Technology, has the highest ranking and coverage in our scorecard review of SDPM capabilities. The natural integration of the SDPM layer in the overall PLM framework provides additional benefits for the sophisticated user willing to work with the full capabilities of PLM concepts. Linking together requirements management, system engineering, product design, simulation, manufacturing, and

support represents the core capabilities targeted by Teamcenter. Teamcenter for Simulation perfectly covers analysts' needs in that environment.

DASSAULT SYSTÈMES/SIMULIA

Dassault Systèmes/SIMULIA offers a visionary approach to SDPM. DS/SIMULIA's Simulation Lifecycle Management (SLM) does not simply provide a PDM tool to analysts; it consistently focuses on the support of the analyst's work process and on coordination with others driving product development in the company. Beginning with project tasks and work breakdown structures, all the data necessary to execute work is linked at the right place and made available at the right time to execute simulation work. There is no hassle for the analyst to deal directly with data management, but everything the analyst does is recorded for traceability. The appropriate links are set to maintain consistency and accurately monitor the maturity of the project.

In contrast to MSC, however, DS/SIMULIA has not yet established solid production references and the product just recently hit the market. Market validation represents the next step that DS/SIMULIA will have to achieve.

ALTAIR

With Altair Data Manager (ADM), Altair achieved a first step for simulation data management, capitalizing on SmarTeam PDM technology and adapting it for the simulation environment. It is not clear, however, that this easy entry approach to data management really did catch the attention of the analysts. Following a company reorganization, the SDPM topic got more attention, and a new product generation will be delivered to the market starting by 2009 year end. Since the offering could not be demonstrated in time to complete our analysis on a consistent basis with the other vendors, the ratings for Altair are presented separately after the full report.

Under a unified environment, the HyperWorks Enterprise product will reconcile all pre-post processor, FEA solvers, and SDPM solutions. This new offering will be based on the HyCube technology, which supports the description of multi-dimensional relationships. That technology facilitates the building of complex simulation data models, and the tracking of data dependencies and processes. While Altair has a long way to go, immediate benefits should be attainable by users with the first release.

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INTRODUCTION

For the third time, CPDA has completed an in-depth analysis of the leading simulation data and process management (SDPM) solutions on the market. This survey involved multiple live demonstrations and intense discussions with the vendors covering sixty criteria in four main categories:

- workgroup process support
- simulation data management
- PLM integration framework
- utilities

The participating vendors were:

- ANSYS, with EKM (Engineering Knowledge Manager) and Workbench V10 (Released Q2 '09)
- MSC.Software (MSC), with SimManager and SimXpert R14 (Released Q2 '09)
- Siemens PLM Software (Siemens), with Teamcenter for Simulation V8 (Released Q3 '09)
- Dassault Systèmes/SIMULIA (DS/SIMULIA), with Enovia SLM V6 R2010 (Released Q2 '09)
- Altair, with HyperWorks Enterprise (to be released Q4 2009/Q1 2010)

All the vendors demonstrated their solutions in live sessions, with the exception of Altair. Altair's new offerings will be delivered in several phases starting at the end of 2009. For this reason, Altair rankings are highlighted separately in the appendix.

This scorecard is a comprehensive evaluation of features and functions that are desirable in an SDPM solution. It includes leading-edge features, and emphasizes process support and integration with other enterprise functions.

The survey covers the available technology proposed by the vendors. It does not include any user's actual experience with the products or their priorities. Their experience and their priorities may differ from the capabilities targeted and now offered by the vendors.

In the coming months, CPDA and the Design Simulation Council will continue to assess actual SDPM implementations. Key issues relate to the cost and complexity of deployment, the ease of use with particular emphasis on the features that integrate with other systems, the degree of customization and configuration required, and the level of out-of-the-box functionality.

THE SLOW ADOPTION OF SDPM

The adoption of simulation data and process management tools has been slow, with only a few production sites referenced by the vendors, and that generally have limited experience and deployment. After four years of efforts and discussion within the Design/Simulation Council, and despite early agreement on the priority expressed by the users to adopt a framework based on SDPM, the level of implementation by the users is disappointing.

On the vendors' side, it took much more time and effort than anticipated to advance the technology to a level such that simulation engineers could make full use of it. Data management tools were too complex and difficult to parameterize for simulation work. Process support was light or absent.

Given the recent progress achieved by all the vendors, the situation has changed. There are now capable solutions to enable the adoption of good practices for simulation data and process management. Established on a sound technical foundation, a large set of functions is available with different levels of capabilities to match various levels of product design complexity, simulation work volume, or human resources available. From simple data file and reports management up to the configuration management of analysis models, users should be planning an appropriate road map for their best use.

WORKGROUP PROCESS SUPPORT

The simulation engineers, or analysts, represent a highly specialized community too often isolated from other mechanical engineers. The isolation applies even more within large projects that tend to distribute effort between the project team and sub-contractors, requiring significant effort to make sure enough collaboration takes place.

Given several prevalent practices, the payoff of a design/simulation framework appears to be substantial. Today, simulation data often belongs only to individual simulation engineers, rather than being shared for reuse in an organized approach. The data is not managed at a workgroup level, and access by other enterprise stakeholders is generally not even considered. Simulation procedures and best practices may be documented, but the actual adoption of standard work automation is quite low. This is in part because simulation engineers are faced with high complexity and detail in simply using the simulation applications, which slow the initial efforts. At the same time, the complexity justifies the broad adoption of standard work and dramatically raises the ultimate payoff.

The latest SDPM tools may greatly alleviate these challenges. First, they can organize and manage the data, relieving the individual of much non-value-added work. Second, they provide process support so that simulation tasks can be automated. Workflows can be created that not only reduce complexity and required attention to detail; they greatly improve collaboration within workgroups and communication with other engineering functions.

Many engineers reluctantly spend time organizing their data and formalizing their processes so that other mechanical engineers can leverage the effort and make use of it. Their preferred area of work relates to either complex model building with multi-physics problem resolution, or optimization. Although rare today, one does find experts in differential equations developing new algorithms for simulation outside of the vendor community. This situation is justified in some situations, where simulation is still a research effort. That applies to multi-disciplinary optimization, or other advanced physics simulations requiring a very high level of expertise to define the right idealized model, setting the conditions and understanding the results. Indeed, when the objective of simulation is to capture complete realistic behavior better and more precisely, a small error or wrong assumption may lead to completely wrong conclusions. That objective requires more detail in terms of both material and system characteristics that lead to non-linearities, instable model, multi-physics interactions, and multiple levels of fidelity optimization loops. All these challenges require deep experience and a high level of expertise that is not common in most companies.

On the other hand, a significant volume of analysis is performed with models validated a long time ago that are stable and easy to master. This is the area where SDPM tools offer their best value and support a significant return.

The survey reviews the support of standard work procedures as well as change management capabilities covering:

- work procedure definition
- method capture and re-use
- process design and execution
- types of processes supported
- simulation execution on the grid or HPC (high performance computing)
- PLM change initiated from simulation
- PLM change propagation to simulation

To define standard work procedures and to make them available to the project engineers, all vendors support the description and execution of work processes. The capability of designing the process relies at minimum on a graphical user interface encapsulating a scripting language. Three vendors support a complete and advanced description of a set of process activities based on pre-defined actions available through the dragging and dropping of icons. All vendors support the execution on a grid or HPC with resources management. All vendors also support CAE model building or the model assembly process, as well as processes involving multi-physics, optimization loops, or stochastic studies.

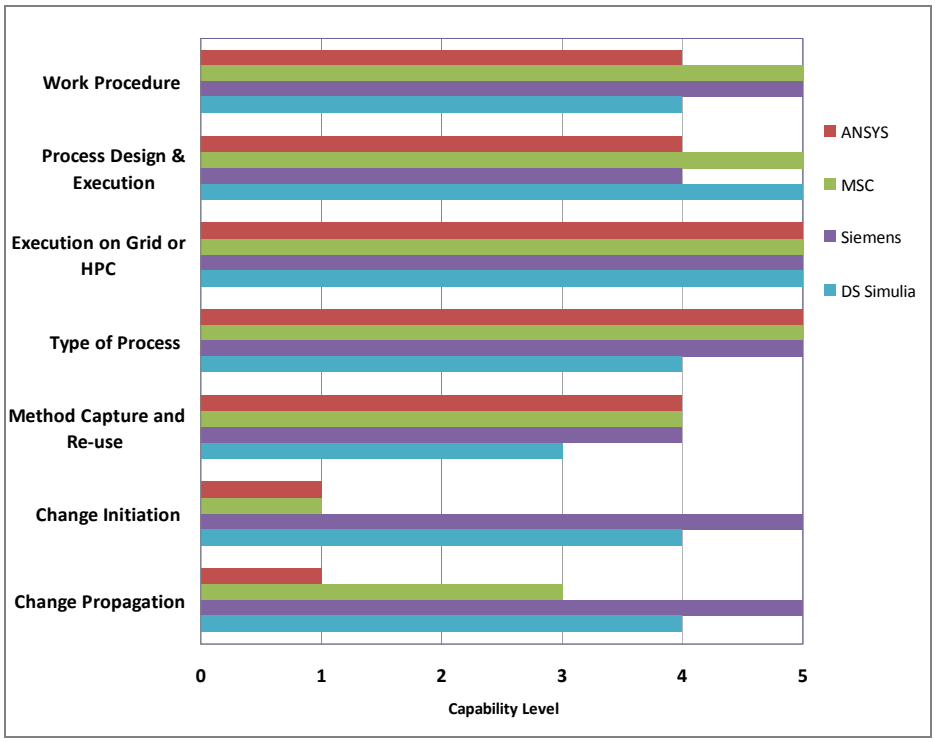

FIGURE 1
Vendors' Delivered Capabilities Covering Workgroup Process Support

All vendors have achieved excellent progress in workgroup process support over the last two years, with the main differentiation deriving from the change management capability that is best supported by a PLM-based solution. The initiation and propagation of a change request from or to the simulation group is well supported only by two vendors with:

- change process definition and execution capability
- change process synchronization capability
- compatibility with standards for communication and exchange

Other vendors provide only limited functionality:

- status highlighted by visual marker
- user notification through email
- change process based on status change

SIMULATION DATA MANAGEMENT

Simulation data management (SDM) represents the core of capabilities required for a good design and simulation integration framework. It is also the first step that can be achieved by a company willing to deploy SDPM along a progressive road map. Defining a simple data model containing input data files, solver execution parameters, and results files represents the first elementary step that many companies have reached. The real start of a significant payoff relates to the management of simulation models' components such as mesh areas, elementary loads, and simulation conditions that allow various combinations, and their reuse

for multiple simulation runs based on the products' options and variants or optimization studies. Managing the configuration of those components of the simulation models ensures a significant time saving and increases the quality and reliability of the simulation work.

The survey looks at the following major aspects of SDM support:

- Data organization capabilities required to support simulation data model design in terms of defining the data types and attributes
- Simulation structural design covering the organization of the data within a hierarchy, and the relationships, rules for the configuration of simulation models, management of links and dependencies, and the handling of meta data
- Data lifecycle support, covering the data history that keeps track of all changes, versioning, and maturity level status
- Underlying database technology that must ensure at minimum the secure vaulting of simulation files and meta data in a repository, which may extend to the support of multi-site distribution of the data, and proper user identification for data access control
- Multi-disciplinary support with data sharing across disciplines and data formatting for the preparation of input files for various solvers
- Search capability for similar work among simulation models for re-use and sharing of data across disciplines and projects
- Links to PLM, starting from simple data extraction and loading, and extending to the import of other product structures, change process propagation, and configuration management synchronization

The core of the simulation data management capabilities is very well covered by all vendors, but the link to PLM is still an area meriting additional progress, as further detailed in the next section below. Also, multi-disciplinary support needs to be further enhanced.

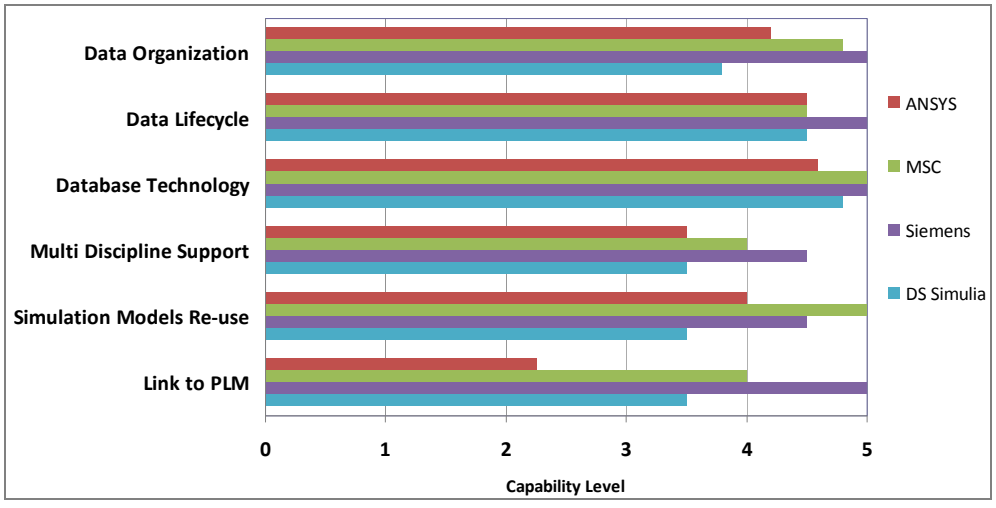

FIGURE 2
Major Aspects of Simulation Data Management

PLM INTEGRATION FRAMEWORK

Looking at the big picture of PLM, starting with requirements management through systems engineering, and proceeding through all phases of product development, the simulation data and processes are still quite isolated. That is reflected in the category's overall ratings, which show several criteria with the lowest average.

Currently, three vendors directly address the integration and management of requirements with simulation data and processes, with the other vendors relying on a simple data exchange through Excel spreadsheets.

- MSC and Siemens support bi-directional relationships with live links based on APIs or open services support (Open/PDM).
- DS/SIMULIA supports a direct link from its own requirements management tool and DOORS.

The same results apply to the integration of requirements with test requests and test results.

Systems engineering models are not linked with simulation, except for Siemens and partially for DS/SIMULIA, despite an obvious need to correlate high level system model simulation and design solution simulation.

On the other hand, all vendors integrate mechanical design and simulation integration very well as the most advanced capability in this area:

- The extraction of a geometric model from CAD and the tracking back to the CAD model of changes from simulation is completely supported by four vendors with a bi-directional link and by a direct link for the fifth, Altair, with their forthcoming release.
- The tracking of CAD model structure and simulation model structure for changes is supported by three vendors; MSC, Siemens, and DS/SIMULIA, by comparing the specific tree structures and the automatic notification of changes.

The extraction and loading of the characteristics of the CAD geometric model (e.g., material characteristics) is covered by two vendors (Altair, with their forthcoming release, and ANSYS) by directly importing meta data, which is rated as a level 4 capability. Three vendors (MSC, Siemens, and DS/SIMULIA) extend the capability to level 5 with customizable functions for data extraction and loading based on rules.

The comparison of CAD and simulation models for changes is supported by highlighting geometric disparities for ANSYS (level 3), by feature recognition for Altair (level 4), and through full model comparison and reporting for MSC and Siemens (level 5).

The integration of simulation with physical test activities is very well supported by all vendors:

- Links between simulation results and test results are established by all vendors.
- Links between simulation and test requests with direct links across databases are supported by MSC and DS/SIMULIA.
- Process support for the management of simulation and test requests is supported by Siemens and is planned by Altair in the future.

As a special note, the correlation of simulation and test results is supported by DS/SIMULIA through automatic correlation functions such as the detection of gaps or a mismatch based on reference points or key words.

The integration with other CAE COTS, or commercial off-the-shelf simulation tools, is performed through direct data loading from other databases and applications. The integration relies on direct APIs to extract or send data from or to running applications, including out-of-the-box connectors based on this API, to most CAE solutions on the market for MSC, Siemens, and DS/SIMULIA. This is rated as a level 5 capability.

Strong progress has been made on simulation and test data mining and re-use, with all vendors' ratings at level 4 or 5:

- Data source tracking with change tracking and automatic update notification may be invoked through subscriptions.
- Search and query functions include multi-conditional criteria that can build and also be saved.

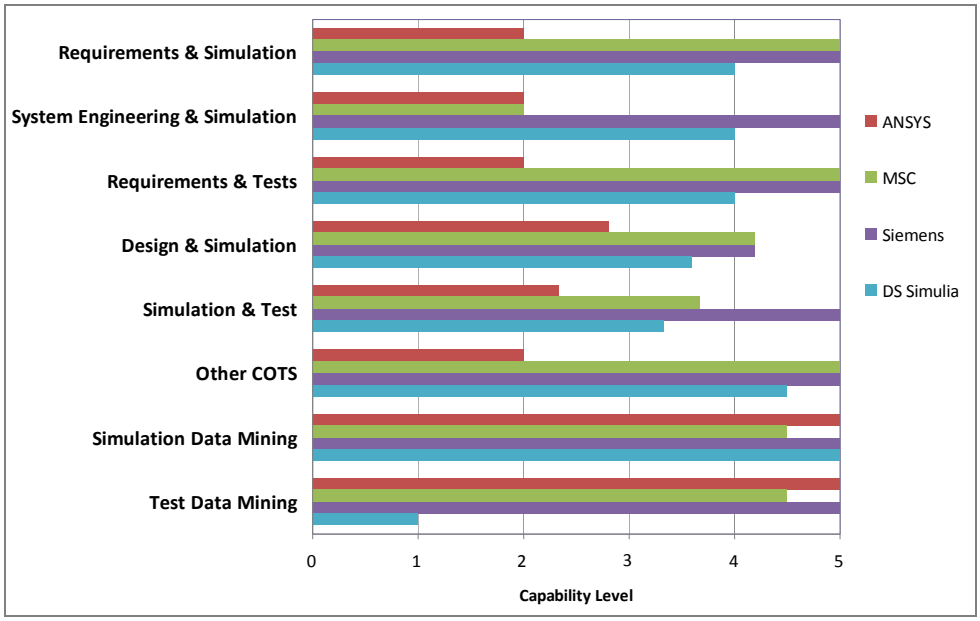

FIGURE 3
Vendors' Delivered Capabilities Covering PLM Integration

UTILITIES

A number of utility functions have been identified that significantly increase the payoff of deploying SDPM solutions by simplifying some tasks and reducing manual work:

- Data exchange functions for reformatting input and output data for pre-processing files, building solver data decks, or transforming CAD geometric models
- Specific CAE COTS integration (Abaqus, ANSYS, HyperWorks, MSC Nastran, and NX Nastran)
- Specific PLM COTS integration (Enovia, Teamcenter, Windchill)
- Visualization of CAD and CAE models
- Collaboration functions for data and process access and execution
- Report building including KPIs

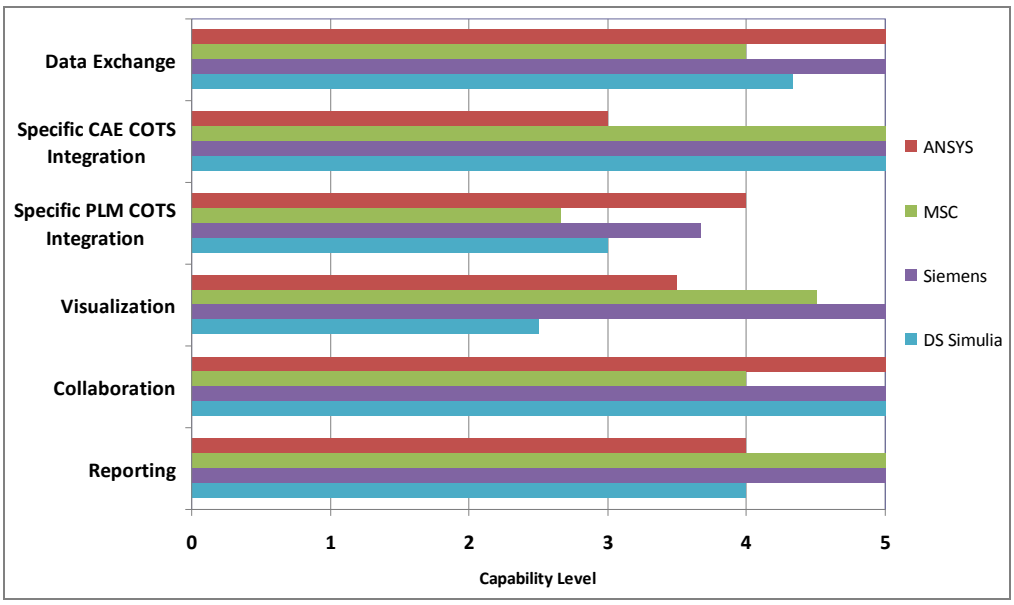

FIGURE 4
Vendors' Delivered Capabilities Covering Utility Functions

Significant progress has been achieved by all vendors on data exchange and other CAE tool integration. The main current weakness relates to the PLM integration, where all vendors have a low rating except for ANSYS and Siemens.

HIGHLIGHTS OF INDIVIDUAL VENDORS

ANSYS

ANSYS Engineering Knowledge Management (EKM) together with Workbench does an excellent job at targeting the analyst workgroup. It is a pragmatic approach. For Workbench users, the extension of scope to EKM should be readily appreciated. Strong emphasis has been put on reusability, making it easy to use and automate for a large number of standard simulation tasks. The integration with other solvers, CAD, and PDM tools is also well covered.

MSC.SOFTWARE

Among all vendors, MSC.Software represents the company that first understood the necessity of managing simulation data and process. MSC has invested heavily in the area ever since.

Opening new markets and introducing new technologies always involves a challenge and the first deliverables years ago were generally incomplete and not always based on sound technology. After several years of perseverance in gaining market awareness, MSC can now be proud of the result. Especially considering that MSC is not a general purpose PLM vendor, its achievement in mastering data and process management is remarkable.

The combination of SimXpert for process support of simulation work and SimManager for data and process management provides a complete and fully operational solution. Moreover, MSC has the largest number of sites using SDPM in production on the market. Large aerospace and automotive companies rely on MSC SDPM tools for supporting a tremendous increase in the volume of simulations to be performed with tangible and measurable benefits.

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The natural integration of the SDPM layer in the overall PLM framework provides additional benefits for the sophisticated user willing to work with the full capabilities of PLM concepts. Linking together requirements management, system engineering, product design, simulation, manufacturing, and support represents the core capabilities targeted by Teamcenter. Teamcenter for Simulation perfectly covers analysts' needs in that environment.

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That approach covers every step of design and all levels of simulation for all disciplines, from the part level through the system and to the global product. In contrast to MSC, however, DS/SIMULIA has not yet established solid production references and the product just recently hit the market. Market validation represents the next step that DS/SIMULIA will have to achieve.

APPENDIX

ALTAIR

With Altair Data Manager (ADM), Altair achieved a first step for simulation data management, capitalizing on SmarTeam PDM technology and adapting it for the simulation environment. It is not clear, however, that this easy entry approach to data management caught the attention of the analysts. Following the company's reorganization, SDPM got more attention, and a new product generation will be delivered to the market starting by 2009 year end. The ratings for Altair are presented separately as the offering could not be demonstrated in time to complete our analysis on a consistent basis with the other vendors.

Under a unified environment, the HyperWorks enterprise product will reconcile all pre-post processor, FEA solvers, and SDPM solutions. This new offering will be based on the HyCube technology, which supports the description of multi-dimensional relationships. That technology facilitates the building of complex simulation data models, and the tracking of data dependencies and processes. While Altair has a long way to go, immediate benefits should be attainable by users with the first release.

Figure 5, on the following page, charts out Altair's planned capabilities.

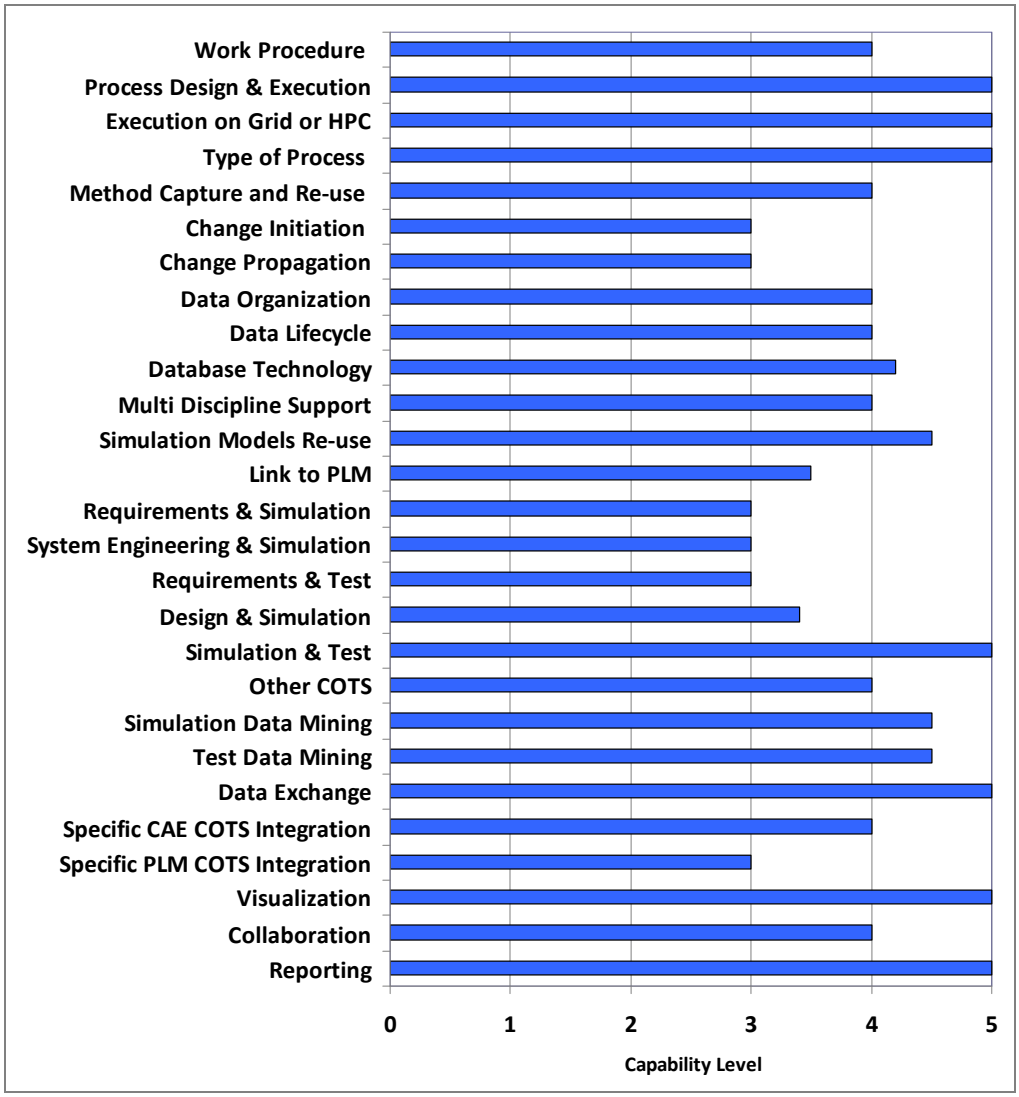

FIGURE 5
Altair's Planned Capabilities in Simulation Data and Process Management