PLM Obsolescence Management Phase 1 Research Report

Initial Model and Current State Assessment

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Aerospace & Defense PLM Action Group

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INTRODUCTION

PLM Obsolescence Management for the purposes of this research is defined as the ability of an A&D company to upgrade and transition their PLM solution to new technologies in multiple increments over a period of several decades without loss of data and without incurring excessive cost and effort.

PLM Obsolescence Management is a major topic of concern in industries where the lifecycle of the company's product information is longer than the lifecycle of the PLM solution technology used to manage that information, and where the cost of a complete technology change is very high. Both conditions apply within the A&D industry. Key motivations for member investment in this topic include:

- The ability to refresh PLM enabling technology incrementally over time instead of a complete and costly swap out
- The ability to access and interpret product definition information over decades of technology refresh projects.

Within its 2014 research agenda, the A&D PLM Action Group identified PLM Obsolescence Management as a high priority topic. The Group commissioned CIMdata to conduct research to identify the most important causal factors contributing to the negative consequences of PLM technology obsolescence; solicit and document historical experiences; and research current strategies and tactics for managing technology obsolescence.

CIMdata's research relied on the A&D Action Group members as sources to be surveyed and interviewed. Methods were applied to avoid disclosing each company's product and process strategies to other members. A similar approach was used to obtain perspectives of the three major PLM software providers and three major systems integrators.

This report presents an initial model for PLM obsolescence management, an assessment of the current state, summary observations, conclusions and recommendations.

RESEARCH GOALS AND METHODOLOGY

The following goals and methodology were defined and agreed with the Members and documented in the project plan in advance of project approval and initiation.

Research Goals

The overall goal of this research was to develop a definition of the major causal factors contributing to the negative impacts of PLM technology obsolescence and to survey the current state of obsolescence management. More specifically the goals of this research were to:

- Understand the causes of high cost and risk of data loss associated with PLM technology obsolescence and the relative impact of the top causes on A&D OEMs
- Understand the strategies and tactics employed by industrial companies for managing PLM technology obsolescence
- Document a historical perspective and fact base as a baseline for setting future goals
- Understand the current perspective of PLM solution providers (i.e. PLM software providers and systems integrators) regarding this topic
- Develop a model of causal factors and mitigation methods associated with the negative impacts of PLM technology obsolescence
- Develop initial policy, process and technology insights for managing PLM obsolescence

Methodology

CIMdata used the A&D Action Group members as sources to be surveyed and interviewed, without disclosing each company's product and process strategies to other members. A similar approach was applied to obtain perspectives of the three major PLM software providers and three major systems integrators. The members each appointed a contact person to coordinate with the CIMdata team.

Gather PLM Obsolescence Management Information

The CIMdata team developed a survey to identify causal factors, their impacts, and current strategies to mitigate them in the context of a PLM technology refresh. The survey addressed four topics: 1) causal factors contributing to the cost of technology refresh; 2) mitigation methods to minimize the impact of these factors; 3) causal factors contributing to the risk of product data loss; and 4) mitigation methods to minimize the impact of these factors. The survey topics corresponded to the structure in Figure 1. The survey questions were relatively open ended. Questions regarding the identification of causal factors of technology refresh costs drew upon knowledge gained from CIMdata's previous PLM Investment Sustainability research. Questions regarding risk of product data loss included knowledge gained from Long Term Archiving (LOTAR) research. Questions were included to solicit supporting insights from historical experience.

The survey was distributed to A&D PLM Action Group member company subject matter experts (SMEs), to appropriate representatives from the three major PLM software providers (i.e. Dassault Systèmes, PTC and Siemens PLM Software), and to appropriate

representatives from the three major systems integrators (i.e. Accenture, Capgemini and Tata Consultancy Services). CIMdata conducted telephone interviews with SMEs from each A&D PLM Action Group member company, technology supplier and system integrator to discuss, elaborate, and clarify causal factors and mitigation methods.

Develop PLM Obsolescence Management Model

The CIMdata team developed a model of the top five (5) causal factors and top five (5) mitigation methods identified in the interviews for each of the two negative impacts of PLM technology obsolescence that are the subject of this research. The model includes names and definitions of the five highest-ranking causal factors and mitigation methods as identified in the surveys.

Assess Current State

CIMdata documented an initial assessment of the impact of causal factors, the difference in perspectives between the OEM members and their solution providers, the perceived level of control of the members versus that of the solution providers, and trending over time. This commentary was based on the member, technology supplier and system integrator survey and interview responses, and augmented by CIMdata's experiential knowledgebase.

Prepare Report

CIMdata prepared a full report for the Members and an overview report for non-members who participated in the research as survey respondents. These reports are available in both document and presentation format. This document is the full report for Members.

PLM OBSOLESCENCE MANAGEMENT MODEL

The PLM Obsolescence Management model structure, consisting of *negative impacts*, *causal factors* and *mitigation methods* as shown in Figure 1, was defined when this research project was planned and provided the framework for the survey questionnaire. The survey responses and interviews have provided the model content.

Respondents were asked to list and rank causal factors and mitigation methods. Analysis yielded a ranked "top 5" list in each category for each of the two negative impacts.

The model, at this stage of development, is primitive, representing nothing more than the concept that *causal factors* increase the negative impacts and *mitigation methods* decrease the negative impacts of PLM technology obsolescence. A description is provided for each model element, but there are no defined variables or functional relationships; nor are there defined linkages between causal factors and mitigation methods. These fundamental mechanics of the model will be the subject of future research.

Overview

PLM technology obsolescence is a positive phenomenon because obsolescence occurs when new solutions are available that can improve business operations. However, there are substantial negative aspects to a company's response to technology obsolescence.

Those are 1) the cost of the technology refresh to obtain those business improvements, and 2) the risk of data loss when migrating to a new solution. Obsolescence management is the set of policies and practices by which these negative aspects are controlled and minimized.

The scope for this initial research project was limited to identifying and documenting the top five causal factors and top five mitigation methods that affect each of the two negative aspects of a company's response to technology obsolescence. The elements of this model and the basic relationships between them are shown in Figure 1.

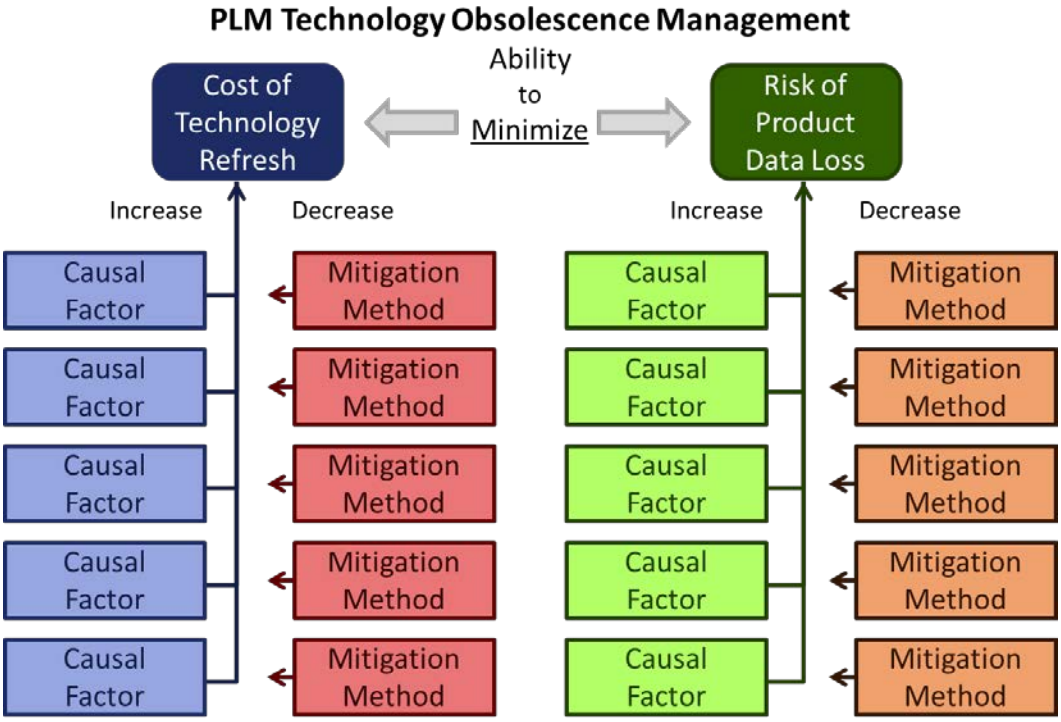

Figure 1 – PLM Obsolescence Management Model

Cost of Technology Refresh

The cost of technology refresh is composed of many elements, including software licenses, required middleware and hardware changes, system redevelopment and deployment, data cleansing and migration, and user training.

Causal Factors

The top five causal factors that increase the cost of technology refresh, according to Member opinion, are as follows.

#1 Heavy customization of PLM solution

Description

Customizations are changes made to a software application's function or behavior that always need to be tested and often need to be modified when a system is upgraded. Typically changes to core application code, programs that access the core API, and data model or data structure changes fall within the scope of customization. In contrast, configurations are non-programmatic tailoring of an application's function or behavior that do not require modification or significant testing when a system is upgraded.

Impact

Customizations can provide significant near term benefits for competitive differentiation and improved user acceptance. Longer term, the cost, effort and disruption of modifying and testing customizations during system upgrades can be very high.

#2 Multiple unique implementations of PLM solution

Description

Multiple PLM solutions, when implemented within a company, may be based on the same application set from a single PLM solution provider, or on different application sets from multiple providers. When based on the same application set, the multiple instances will have been configured differently, with different customizations, data models, and attributes.

Impact

Depending on the degree of difference between implementations, the cost, effort and disruption of a system upgrade can vary from a modest increment for each instance to a complete duplication for each instance.

#3 Numerous & complex integrations

Description

PLM solutions are typically made up of many different software applications linked together to create and manage the product definition over its lifecycle. A cPDm (Collaborative Product Definition Management) application captures and coordinates the information from the different software applications used to define and modify the product definition. Integrations are created between the cPDm solution and these authoring applications. Additional integrations are created to support sharing of PLM data with other enterprise solutions like ERP and CRM. These integrations utilize various protocols and middleware tools to extract information from one application and deliver it to another.

Impact

Some integrations, especially between authoring applications and the cPDm application, are offered as commercial products by a PLM solution provider. Almost all other integrations are custom point-to-point implementations ranging from medium to high complexity. As the number and complexity of these implementations increase, the cost, effort and disruption of a system upgrade can become very high.

#4 Non-standard metadata structures in PLM solution

Description

Within the PLM solution, metadata are commonly represented as a simple data field linked to an underlying data object. Data structures are the connections between data objects and data fields. Commercial PLM applications support a range of metadata field representations and data structures that are customary within the aerospace and defense industry. Ideally, a PLM solution implementation only allows a standard set of metadata and data structures to be created. In reality, business requirements sometimes force, and or lax design policies allow, implementation of deviations as customizations.

Impact

Customization of metadata representations and data structures can provide significant near term benefits for competitive differentiation and improved user acceptance. However, like other customizations, in the longer term, the cost, effort and disruption of modifying and testing these customizations during system upgrades can be very high.

#5 Inclusion of business process reengineering

Description

New versions of commercial PLM enabling applications can support new and improved business processes. In addition, implementing a PLM solution upgrade always requires some level of user training and change management. Recognizing the improvement potential and the inevitability of some investment in organizational change, a PLM solution upgrade is often viewed as a good opportunity to introduce new and improved business processes. For some improvements, process and technology change can be executed independently. For others, they must be executed simultaneously.

Impact

Changing process and technology at the same time can provide significant near term benefits for competitive differentiation. However, the cost, effort and disruption of changing both at the same time can be higher than changing each separately. Also, the level of disruption and natural resistance to change elevate the risk of project failure.

Mitigation Methods

The top five mitigation methods that decrease the cost of technology refresh, according to Member opinion, are as follows.

#1 Consolidate ownership of PLM architecture

Description

In large companies, it is often the case that separate organizations with separate budgets and objectives are responsible for development, implementation and support of the various elements of the enterprise PLM solution architecture. Examples of the types of organizations that are typically involved include business functions focused on engineering, manufacturing, and service, as well as IT functions focused on applications, networks, servers, and desktops. A consolidated ownership means that all the organizations responsible for the various PLM solution elements operate within a single governance structure.

Impact

A single governance structure provides a mechanism for definition and enforcement of policy to reduce the amount of customization, increase implementation uniformity, reduce the number and complexity of integrations, and increase standardization of metadata representations and data structures. To the extent that such policies are established and enforced the effect on several causal factors can be large.

#2 Best in class PLM software procurement policy

Description

Across the complete enterprise scope of PLM, application software is typically purchased from multiple providers based on a best in class strategy because no single provider has the right mix of software products to meet the requirements of a large company.

The cPDm, design authoring and manufacturing engineering application suites are frequent exceptions. Many companies procure a complete cPDm application suite from a single provider, and some extend the single provider strategy to CAD and digital factory applications as well.

Impact

Members ranked this mitigation method highly, but failed to provide a rationale for their opinion.

#3 Partnership with software providers to influence product

Description

The major PLM software providers have established organizations and processes that allow large customers to influence their product development roadmaps. Through this

mechanism, customers submit requirements for advanced product features and functions that are important to their future business objectives. Each software provider makes an internal evaluation and includes new requirements into their product roadmap that they judge will increase market revenue.

Impact

Members could use this method to apply financial pressure on PLM software providers to comply with data, data exchange, interface and other architectural requirements, thereby reducing the cost of system upgrades. For this method to be successful, members must clearly articulate their requirements and promote a broad based and firm policy that these requirements are major criteria in their procurement evaluations.

#4 Standard data formats for storage and exchange

Description

STEP is generally considered the foundational standard for PLM information storage and exchange, and has gained broad adoption over the past many years, especially in Europe. JT and 3DPDF are visualization standards that are proving very useful for many real time collaboration processes and data exchange, and are rapidly gaining broad adoption. All major PLM software providers offer commercial capability for conversion of their native format files into these standard formats.

Impact

Storing PLM data in standard formats reduces the cost, effort and disruption of data cleansing and migration during a PLM system upgrade.

#5 Commercial middleware for interfaces

Description

Commercial middleware is a class of software that provides functionality to enable integration of enterprise software solutions including PLM, but extending well beyond PLM. It allows software applications to exchange data with any other applications also connected to the middleware using a common technology base and protocol. Utilization of commercial middleware can dramatically reduce the number and complexity of integrations when compared with a point-to-point integration methodology.

Impact

Reducing the number and complexity of integrations in the PLM solution reduces the cost, effort and disruption of interface development and testing during a PLM system upgrade. For this method to be successful, members must develop and implement comprehensive data and interface standards within the middleware and assure compliance of all applications that interface with the middleware.

Risk of Data Loss

The risk of data loss is composed of many elements, including data corruption, algorithm changes that process data differently, and data no longer supported by an application, or lack of application to process data.

Causal Factors

The top five causal factors that increase the risk of data loss, according to Member opinion, are as follows.

#1 Advanced features imbedded in native data structures

Description

For competitive and performance reasons PLM software providers implement proprietary data structures within their products. When they develop new and innovative functions and features, they sometimes are not able to use standard formats and data structures. Even the provider's proprietary data formats and structures are not stable across versions of their software applications. As a result, extracting and transforming product information to be compatible with another application is complex, and the methods and tools to do so are often custom and unstable over time.

Impact

The non-standard data formats and structures across PLM software applications and the instability of data formats and structures across versions within a single provider's applications introduces very high risk of data loss over iterations of PLM systems upgrades.

#2 BOM hierarchy incorrect (i.e., multi-level becomes single level, quantities incorrect)

Description

When data is transferred from one application to another within a PLM solution, all the structure and data does not always transfer successfully. This can occur in the context of an integration or a migration. The primary cause of this loss is that the data representation is different between the applications. This appears to be a consequence of *Advanced features imbedded in native data structures*.

Impact

In the case of an integration, the full context of the data may be lost if the source system contains more information than the target. On the other hand, if the target system requires additional information that does not exist, the business process will pause until the required information is input.

It can be argued that the occurrence of this condition, whether actual or feared, is a deterrent to full data migration and, therefore, a "cause" of data loss due to incomplete data migration.

#3 Data authoring application is no longer available

Description

Some PLM software providers pursue a discontinuous innovation strategy and data compatibility across application versions is not guaranteed. In addition, from time to time, PLM software providers will discontinue an application without migration methods or tools.

Impact

Data format and structure inconsistency across PLM software application versions introduces risk of data loss. Data inconsistency across versions without provider supplied migration methods and tools introduce high risk of data loss. Data format inconsistencies across multiple software versions over time compound the risk of data loss, even with supplier provided migration methods and tools.

#4 Data intelligence is lost (e.g. feature data or object relationships)

Description

CAD feature and object relationship data is often proprietary and not defined in current standards so there is not an easy way to transfer this information between systems. This appears to be a consequence of *Advanced features imbedded in native data structures*.

Impact

In the case of an integration, the full context of the data may be lost if the source system contains more information than the target. On the other hand, if the target system requires additional information that does not exist, the business process will pause until the required information is input.

It can be argued that the occurrence of this condition, whether actual or feared, is a deterrent to full data migration and, therefore, a "cause" of data loss due to incomplete data migration.

#5 Data or metadata inconsistent, violate creation standards

Description

Multiple issues cause the inconsistency including, lack of organizational discipline, unclear or changing definition of what data or metadata information should be. Lack of data validation processes allowed invalid data to be created.

Impact

If definitions are incorrect or data or metadata are inconsistent, then meaning of the data is ambiguous causing confusion and lack of confidence in the data.

In addition, inconsistent data or metadata creates additional cost due to confusion and can create errors in downstream processes if the data is wrong.

Mitigation Methods

The top five mitigation methods that decrease the risk of data loss, according to Member opinion, are as follows.

#1 Supply chain uses standard authoring applications

Description

Large OEM organizations commonly require their supply chain to use specific data authoring software and follow data creation standards that are identical to those used internally by the OEM.

Impact

A policy that assures all data whether created internally or externally by a supplier is in the same format and conforms to the same data creation standards allows for implementation of a single comprehensive approach for reducing the risk of data loss during system upgrades.

#2 Partnership with software providers to influence product

Description

The major PLM software providers have established organizations and processes that allow large customers to influence their product development roadmaps. Through this mechanism, customers submit requirements for advanced product features and functions that are important to their future business objectives. Each software provider makes an internal evaluation and includes new requirements into their product roadmap that they judge will increase revenue.

Impact

Members could use this method to apply financial pressure on PLM software providers to comply with data standards (e.g. LOTAR, STEP or JT), increase data consistency across versions, and provide improved data migration methods and tools, thereby reducing the risk of data loss during system upgrades. For this method to be successful, members must clearly articulate their requirements and promote a broad based and firm policy that these requirements are major criteria in their procurement evaluations.

#3 Virtual or physical legacy system implementations

Description

Maintaining a series of historical environments that replicate the exact software and hardware configurations within which legacy PLM data was created assures that the repository of design files can be accessed, viewed and manipulated as needed over a period of several decades. These environments can be physical or virtual. Virtualization technology allows encapsulation of a complete server and software environment within specialized utility software on a specialized server.

Impact

Within the limits of availability and reliability of the legacy environments access to legacy PLM data is preserved and the risk of data loss is low. However, the utility of legacy data is dependent on the effectiveness of cross-version data migration methods and tools.

#4 Comprehensive data-aging plan

Description

Data aging is commonly known as Long Term Archiving or LOTAR. The concept is to ensure that important data will be accessible by converting it into standard, well-defined formats that will be accessible long into the future.

Impact

LOTAR enables any of a variety of data-aging strategies. The assured persistence of LOTAR over the long term is one of its primary advantages. PLM data converted and stored in LOTAR format will persist reliably over the long term, minimizing the risk of data loss. However, some information is lost in the conversion.

#5 Single provider PLM software procurement policy

Description

Across the complete enterprise scope of PLM, application software is typically purchased from multiple providers based on a best in class strategy because no single provider has the right mix of software products to meet the requirements of a large company.

The cPDm, design authoring and manufacturing engineering application suites are frequent exceptions. Many companies procure a complete cPDm application suite from a single provider, and some extend the single provider strategy to CAD and digital factory applications as well. Since the software provider has integrated their suite of PLM application, the data formats and structures are consistent. The result is a broader range of PLM data created and maintained in consistent formats and structures.

Impact

A strategy that extends the scope of PLM data created and maintained in a consistent format allows for implementation of a more comprehensive approach for reducing the risk of data loss during system upgrades.

CURRENT STATE ASSESSMENT

This section provides an initial assessment of each of the model elements, including a summary description of current state, trending over time, and the perceived level of control of members versus solution providers. The assessment presents and compares the perspectives of the members and their solution providers. Wherever possible, the assessment includes an historical perspective and fact base, derived from the survey responses and follow up interviews, from CIMdata's knowledgebase and from other sources.

All four A&D PLM Action group members responded to the survey, and all four participated in follow up interviews. Airbus submitted a response from each of its three divisions: Airbus (commercial), Defence & Space, and Helicopter. Gulfstream submitted two responses: one business oriented and one technically oriented. Boeing and Embraer each submitted a single response.

The three major PLM software providers were invited to participate: Dassault Systemes, PTC, and Siemens PLM. PTC and Siemens PLM responded to the survey, and Siemens PLM participated in a follow up interview. Five systems integrators were invited to participate: Accenture, Capgemini, IBM, HP and TCS. Accenture and TCS responded to the survey. Since we received only two software provider responses and two systems integrator responses we are not able to report results for these groups separately.

The survey analysis employed the following methodology to identify and rank the top five causal factors and mitigation methods. Each of the four sections of the survey contained a list of suggested causes or mitigations from which to choose plus the option to add and select "Others". Respondents were asked to prioritize their top five choices in order from 1 to 5, with 1 as the highest priority. For ease of analysis, each prioritized item was given a score that is the inverse of the assigned priority (i.e. #1 priority items were assigned a score of "5", #2 priority items were assigned a score of "4", etc.). The total score for each item is the sum of the individual respondent scores. The total score reflects both the number of respondents who prioritized the item and the priorities that they assigned. Items are ranked according to member score. If more than one item has the same member score, then solution provider score is referenced as the secondary criteria to break the tie and set rank order.

Cost of Technology Refresh

The member scores and ranking of causal factors and mitigation methods for cost of technology refresh are presented below. Also shown for comparison are the combined software provider and system integrator rankings.

Causal Factors

The #1 member ranked causal factor *Heavy customization of the PLM applications* stands far above the rest of the field with a member score of 22. That score indicates strong agreement between the members on the ranking of this item.

Member Rank	Causal Factor	Member Score	SP & SI Rank
1	Heavy customization of PLM solution	(score: 22)	1
2	Multiple unique implementations of PLM solution	(score: 12)	2
3	Numerous & complex integrations	(score: 12)	3
4	Non-standard metadata structures in PLM solution	(score: 9)	- -
5	Inclusion of business process reengineering	(score: 5)	5
- -	Organizational resistance to change	(score: 4)	4

The rankings are well aligned between the members and the solution providers.

For each of the top ranked causal factors, a summary assessment is presented below. The assessment includes descriptions of the current state, opinions regarding trending over time and perceptions of the power balance between members and solution providers. The information has been organized so as to enable the reader to compare the members' perspective and the solution providers' perspective.

#1 Heavy customization of PLM solution

Current state

Member perspective: The customizations were done to meet business needs, but those needs were not harmonized, leading to multiple instances and data models. In some cases customizations were need to support FAA requirements. Business cases were not always well defined to support the customizations.

Overall the costs associated with customization are seen as high, but justifiable. The customizations added needed capability, delivered business value and usually have reasonable ROI. In many cases, the flexibility of the customizations is poor.

Current developers do not have deep understanding of what they are changing, so they struggle to adapt the solution to new requirements.

Solution provider perspective: Extensive customization was done to support industry and local processes. Heavy customization was done with minimal focus on long term support.

The cost of maintaining the customizations is high, but good capability was added that supports current process and performance expectations. The flexibility is poor. Significant effort is spent on maintaining existing capability rather than on process improvements. The customizations make it difficult to leverage new OOTB capability.

A new concern is knowledge capture regarding legacy application customizations for support, upgrade and migration. Knowledge about the applications is shrinking as older staff retires.

Trending over time

Member perspective:

Past 10 years: the cost has been high, but so has value over base solution.

Next 5 years: Members' views are mixed. Some reduction in customization and increased flexibility is possible with new PLM solutions, but it is unclear if additional complexity from the new solutions will overwhelm flexibility gains.

Solution provider perspective:

Past 10 years: The costs have been high and increasing and will continue to be high until customers upgrade to current PLM solution versions.

Next 5 years: The costs could decrease if the solutions are properly architected & implemented.

Company vs provider control

Member perspective: The responsibility is equally shared.

Solution provider perspective: The responsibility is 80% Customer, they should change processes to leverage OOTB capabilities to reduce customizations.

CIMdata observations

Overall, the ROI for customization has been good. A big concern is how to maintain the customizations in the future. The original architects and programmers are no longer around, and the complexity of the code in specialized solutions is difficult to modify without causing errors.

Several solution providers have designed their solutions as core services and applications running on their platform. Applications will run on multiple releases of the platform. Customizations are done at the application level rather than core or platform level. An analogy is an Excel spreadsheet vs. the Excel application. Old Excel spreadsheets have nearly 100% upward compatibility.

Process re-engineering to exploit OOTB is a possible approach to reduce customization but is seen as very expensive and difficult to execute. In addition, optimizing processes to an OOTB solution has the risk of diminishing the advantage of proprietary processes.

Another, longer term alternative approach to reduce customization is to focus more on data architecture and ensure that PLM applications can read and write to a common data format. In other words, implement a standards based architecture.

#2 Multiple unique implementations of PLM solution

Current state

Member perspective: Defense related solutions are contract-specific so standardization is difficult. Members tend to have implementation variations at the program level. When a new program is launched, updated processes and solutions are launched at the same time. Legacy programs tend to stay on the legacy solutions. Negative impacts occur when trying to reuse data from a legacy program in a new program. Shared data is maintained in two places or complex integrations and migration processes are implemented.

Competency focused departments continue to use discipline specific tools that must be integrated. This is a key reason for the long-term rise in costs.

Solution provider perspective: The disparate solutions are due to many reasons including program requirements, acquisitions, and departmental level functions. There generally has not been a valid business case to migrate data onto current solutions and retire the old ones. This results in higher cost due to duplication of skills, resources (licenses, hardware, etc.). Lack of integration adds to cost via increased effort & errors. Lack of integration between disciplines reduces capability for systems engineering. Flexibility is reduced due to complex traceability requirements.

Trending over time

Member perspective:

Past 10 years: Costs have increased due to the additional environments added.

Next 5 years: Costs will decrease for existing capabilities as legacy solutions are retired, but the overall budget will increase due to additional capabilities being added (e.g., discipline specific tools & integrations).

Solution provider perspective:

Past 10 years: Costs have increased due to the additional environments added.

Next 5 years: Costs should decrease in the future due to implementations of more standard/sustainable tools on new programs.

Company vs provider control

Member perspective: Decisions made by the customers ultimately drive the cost, but vendors have control over software technology and architecture that define/control upgrade costs.

Solution provider perspective: Integrated solutions from providers can potentially lower costs, but the customer decisions on what legacy systems to keep and what new capabilities to enable drive the costs.

CIMdata observations

Members acknowledge that they are partially responsible for costs due to not retiring legacy environments, but they see some solution provider responsibility based on their technology architecture and implementation decisions. Some legacy solutions have much better upward data compatibility. Solution providers believe that using their integrated suite and retiring legacy solutions will minimize cost.

Procurement contracts with software providers should incorporate assurance of data upward compatibility across versions. Members need to focus on the complete software development lifecycle included complete data migration and systems retirement. Legacy environments should be treated as transitional with a well-defined shutdown date. Data not worth migrating may need to be recreated in the future. Focusing on a data architecture and standard formats will help with planning.

#3 Numerous & complex integrations

Current state

Member perspective: Point-to-point, proprietary, home-grown, and ad-hoc integrations are common. There can be "thousands" of integrations in a large A&D company. The PLM solution is so complex, that a hot backup environment is too costly to implement. Up to 24-72 hours downtime are required to perform an upgrade. Many different use cases are supported, so flexibility exists, but more and more effort goes into maintenance rather than capability development.

Solution provider perspective: A disparate PLM landscape often requires greater number of integrations to support the required flow of data. Point-to-point and ad-hoc (not standards-based) integration architectures increase the number of integrations as well as associated maintenance costs. Where integrations are not provided, there is often significant manual effort to maintain data integrity across systems.

The dependencies between PLM and other IT platforms (applications and interfaces) are complex to handle and changes are difficult to implement. The impact analysis of a change is difficult and the documentation is often not updated. Over time, the PLM environment becomes less and less flexible, making it difficult to support business requirements and more and more complex to adapt.

Trending over time

Member perspective:

Past 10 years: Application advancements were avoided to preserve integration capability.

Next 5 years: Modern integration frameworks with new technology stacks offer the opportunity to reduce cost and increase flexibility, but stack upgrades will need to provide additional benefits, not just replicate what exists.

Solution provider perspective:

Past 10 years: Costs have increased as integration volume and complexity have increased.

Next 5 years: Integration frameworks are progressively replacing point-to-point interfaces to lower cost and improve flexibility, but this requires a strong PLM IT governance team and requires investments to be made.

Company vs provider control

Member perspective: The Solution Provider is responsible for the integration interfaces/API. The customer is responsible to develop process to use data across PLM solution

Solution provider perspective: A&D companies can help manage the cost of integration by leveraging 3rd party provided integrations (including SOA integration architectures) and minimizing custom point-to-point integrations when possible. Commercial integrations tend to work on upgrade, ad-hoc integrations do not.

CIMdata observations

Selecting a "sustainable" integration backbone provider becomes a critical choice. In many cases the complexity is in the data transformations. An ESB eliminates the basic authentication and other infrastructure issues, but complex transformations end up being point-to-point connections running on a brokered environment. Is ESB sustainability any better than PLM?

#4 Non-standard metadata structures in PLM solution

Current state

Member perspective: The metadata and BOM structures have been significantly customized, and vary a lot due to long lifecycle of products.

Solution provider perspective: The solution and data model varies by program. This impacts the extended supply chain as Tier 1 suppliers must set up specific data models to synchronize with the A&D OEM program data model. Legacy data models, with non-standard metadata and data structures, become hard to replace without significant cost and impact to the supply chain.

Trending over time

Member perspective:

Past 10 years: Customizations are expensive to develop and maintain, but have added a lot of value. Upgrades are very difficult, so flexibility is reduced because new capabilities in later releases cannot be used.

Next 5 years: ESBs help, but still require significant development and support.

Solution provider perspective:

Past 10 years: Non-standard or non-traditional metadata or data structures drive significant cost into operations. Not only does this show up in IT costs related to customization, integration, and maintenance, but it is also reflected in increased supply chain costs associated with providing data in the correct context, structure, and format.

Next 5 years: ESBs will help. Consolidating solutions to an integrated environment will help more.

Company vs provider control

Member perspective: The solution providers have most of the control as it is driven by the architecture of their solutions.

Solution provider perspective: The heterogeneity of product-related information across programs makes the integration complex and costly (across the enterprise systems and within the extended enterprise). A&D companies are increasingly looking to establish a common PLM capability and data models across programs. While the process to move to a common PLM environment will take significant time, there is recognition that the costs of maintaining a fragmented PLM environment and data model add substantial cost and process inefficiencies. Legacy PLM solutions need to be maintained longer to support the program life extensions. At the same time, process and methods need to be continuously harmonized.

CIMdata observations

Members are fearful of giving the solution providers too much control; they already feel they do not have enough. The solution providers believe consolidating to a single, modern integrated solution is the best solution.

If migration and cleansing of all useful data is not possible, then a LOTAR strategy needs to be developed for the data not valuable enough to migrate, but too valuable to discard.

Solution providers did not rank this issue within the top 5, which makes sense as it is a combination of business process and discipline issues, not a technology issue.

#5 Inclusion of business process reengineering

Current state

Member perspective: Business process reengineering is very limited. Even when it is planned implementations are rarely completed, so multiple processes result. At the end, very limited improvement is ultimately gained. This means that when new solutions are implemented few breakthroughs happen, they are often old capabilities built on a new platform.

Solution provider perspective: Business processes have to be updated to leverage new capabilities. If there is a business case to support process change, then the resources to

develop and implement change should be provided. The reality is it is costly and complex to develop and deploy new business processes, so it is rarely done.

Trending over time

Member perspective:

Past 10 years: We have seen high impact on low evolution, the solutions have made a big difference without dramatic business process changes.

Next 5 years: New solutions should make it easier to support process changes.

Solution provider perspective:

Past 10 years: <no response>

Next 5 years: Costs will decrease because the technology will accept process changes more easily, but staffing reductions may result in a net loss of capability.

Company vs provider control

Member perspective: Customers have the control. Middle management has the responsibility, but not the authority or resources.

Solution provider perspective: It is the A&D company's responsibility.

CIMdata observations

The members and solution providers both recognize that business process changes are key to leveraging new technology. The issue is how to get significant process changes approved and implemented.

Lean Manufacturing concepts may be an alternative approach to addressing issues and getting needed changes complete.

Mitigation Methods

The #1 member ranked mitigation method *Consolidate ownership of enterprise architecture* is not far above the rest of the field with a member score of 14. That score indicates only moderate agreement between the members on the ranking of this item. There was not strong alignment of priorities between the members and their solution providers.

Member Rank	Mitigation Method	Member Score	SP & SI Rank
1	Consolidated ownership of PLM architecture	(score: 14)	2
2	Best in class PLM software procurement policy	(score: 12)	- -
3	Partnerships with software providers to influence product	(score: 10)	1
4	Standard data formats for storage and exchange	(score: 10)	- -
5	Commercial middleware for interfaces	(score: 10)	- -
- -	Modular and layered enterprise architecture	(score: 8)	5
- -	Single provider PLM software procurement policy	(score : 7)	3
- -	Strict enforcement of OOTB application implementations	(score: 7)	4

Solution providers ranked *Partnership with software providers to influence product* as their top mitigation method. Members included it within their top 5, but in interviews stated that partnerships are necessary but have not had a big impact.

The solution providers ranked *Single provider PLM software procurement policy*, *Strict enforcement of Out-Of-The-Box (OOTB) application implementations* and *Modular and layered enterprise architecture* within their top 5 obsolescence mitigation methods. Members did not include these.

Solution providers did not rank *Commercial middleware for interfaces*, or *Standard data formats for storage and exchange* in their top 5. This combined with their ranking of *Single provider PLM software procurement policy* at #3 indicates a posture that they can solve all the issues.

#1 Consolidate ownership of enterprise architecture

Current state

Member perspective: Some progress has been made within A&D companies, but it is still a work in process. There is a long road ahead to get to simplified decisions and organizational structures.

Solution provider perspective: The enterprise PLM governance model often remains a challenge and frequently lacks strong sponsorship from top-level management. As a consequence, PLM projects are not able to address all considerations from all stakeholders throughout the full lifecycle (too complex and too long to get the consensus).

Trending over time

Member perspective:

1) Not always applied in the past

2) As a rule they are applied now

3) Working to ensure they are applied in the future

Solution provider perspective:

3) Is being contemplated for the future

Company vs provider control

Member perspective: A&D company's responsibility

Solution provider perspective: A&D company's responsibility via governance

CIMdata observations

The members and solution providers have a different view of history and the current state, but agree that consolidated ownership is the trend for the future. At CIMdata, we see IT and PLM support consolidating and clarifying their roles and responsibilities and in some cases their organizations.

#2 Best in class PLM software procurement policy

Current state

Member perspective: The PLM space is too broad for a single provider to supply all the needed capability. Selections are typically done by business area; in a large organization it is difficult to make selections in context of the whole business. In addition, a single provider would be too powerful. Integrations are and will continue to be required to be built. Impacts include:

1) Best in class provides the best software solution to the end user. It also drives competition in the software industry.
2) We are stuck having to build our own integrations. Unfortunately solution providers are attempting to block new entries rather than expand their partner programs

Solution provider perspective: <no response>

Trending over time

Member perspective:

1) Applied in the past
2) Applied now
3) It will be applied in the future

Solution provider perspective:

1) Applied in the past
2) Applied now
3) It will be applied in the future

Company vs provider control

Member perspective: It is 80% member responsibility, 20% solution provider responsibility

Solution provider perspective: It is the responsibility of the member

CIMdata observations

The rationale for *Best in Class PLM software procurement policy* as a mitigation method for cost of technology refresh is not apparent to CIMdata. In fact, Best in Class solutions generally contribute to increase number and complexity of integrations. In addition, Best in Class applications often have proprietary features, so they contribute to data loss issues.

Solution providers do not like this option. As a reflection of strong emotions sometimes attached to this issue, one Member comment even speculated that lack of interoperability is a software provider strategy to make software more difficult to replace. There are no case studies showing that better interoperability makes a solution more likely to be discarded.

Multiple best in class applications may add some robustness if integrations are done via a single bus connection (i.e., commercial ESB middleware). If this is done, then each best in class application can be upgraded and only requires testing within the application and its "single" connection to the ESB.

#3 Partnerships with software providers to influence product

Current state

Member perspective: The partnerships have not been fruitful. The software providers see A&D needs as unique, and customizations developed under partnerships have not been sustainable long-term. There have been some department level successes. It is difficult to speak to solution providers with one enterprise voice. It will be very difficult to speak with one industry voice.

Solution provider perspective: Partnerships "should" work over the long-term. So far success has been seen at the department level, not the enterprise. Cross-provider cooperation is seen as difficult.

Trending over time

Member perspective:

1) Applied in the past
2) Applied now

3) It will be applied in the future

Solution provider perspective:

Heavy collaboration between A&D companies and PLM software providers has been a consistent theme in the past and today.

1) Applied in the past
2) Applied now
3) It will be applied in the future

Company vs provider control

Member perspective: There is approximately equal responsibility, but partnership seems to provide limited benefit.

Solution provider perspective: Approximately equal, but more inter-solution provider cooperation is needed with a supporting business case for the solution providers.

CIMdata observations

Members and solution providers want this to work, but success so far has been limited at best, according to both sides. Industry focused solutions may help, if they can be implemented and adopted. The A&D PLM Action Group's mission is to provide a single voice from the members to the solution providers. Perhaps this, along with standards and improved solutions will be enough to make partnerships work with resources and capabilities available today.

#4 Standard data formats for storage and exchange

Current state

Member perspective: Different solutions cause issues but environments are getting more consistent. Proprietary formats significantly reduce reuse of data, but do not limit the reuse of designs! Design concepts are shared, so knowledge is used, just not efficiently.

Standard formats when used are successful, although with some issues. Blockers include lack of support from solution providers. Continuous improvement by internal support teams has improved effectiveness of standards based translations.

Solution provider perspective: Formats do go obsolete, and standards by definition do not have cutting edge features. Visualization formats like JT provide a viable, standards based option to support interoperability.

Trending over time

Member perspective:

1) Minimally applied in past
2) Trying now
3) Will be used in the future

Solution Provider:

4) Applied in the past
5) Applied now
6) It will be applied in the future

Company vs provider control

Member perspective: A&D companies need to speak with one voice and drive the use of standards

Solution provider perspective: Responsibility of solution provider

CIMdata observations

Members and solution providers each believe they should lead in this area. It is notable that, unlike the experience with IGES, practical successes have been achieved with STEP. This should be positive motivation for the Members to monitor the status and support continuing development and adoption of the relevant STEP standards.

#5 Commercial middleware for interfaces

Current state

Member perspective: The current experience is that middleware integrations in many cases are just as customized as point-to-point integrations of the past, but it is hoped that recent implementations will prove to be more flexible.

1) The positive impact of middleware is that it has forced a strategy to think about structure
2) Technology and organizational discipline are barriers to correct implementation of integrations
3) OOTB connectors to commercial middleware and publish reusable application interfaces are required for success

Solution provider perspective: <no response>

Trending over time

Member perspective:

1) Applied in the past
2) Applied now
3) It will be applied in the future

Solution provider perspective: <no response>

Company vs provider control

Member perspective: The responsibility is shared 50/50. Solution providers want to provide their own middleware. This can potentially lead to multi-layer middleware integrations.

Solution provider perspective: <no response>

CIMdata observations

Commercial middleware needs to be assessed to see if it truly works as advertised. If it does, then it can become a key enabler for simplification of integrations, and also for mitigating the cost of supporting multiple best in class solutions.

Solution providers must support middleware interfaces to all commercially prominent ESBs, so Members can utilize those ESBs that are compliant with their enterprise architecture standard. OEMs do not want to end up with middleware to middleware integrations, which would add complexity and cost to their implementations.

Risk of Data Loss

The member scores and ranking of causal factors and mitigation methods for risk of data loss are presented below. Also shown for comparison are the combined software provider and systems integrator rankings.

Causal Factors

The #1 member ranked causal factor *Consolidate ownership of enterprise architecture* is tied with the #2 causal factor and does not score far above the rest of the field. The member score of 18 score indicates better than moderate agreement between the members on the ranking of the top two items. There was not strong alignment of priorities between the members and their solution providers.

Member Rank	Causal Factor	Member Score	SP & SI Rank
1	Advanced features imbedded in native data structures	(score: 18)	2
2	BOM hierarchy incorrect (i.e., multi-level becomes single level, quantities incorrect)	(score: 18)	- -
3	Data authoring application is no longer available	(score: 14)	3
4	Data intelligence is lost (e.g. feature data or object relationships)	(score: 14)	- -
5	Data or metadata inconsistent, violate creation standards	(score: 12)	1
- -	Data and file corruption (e.g., model cannot be opened or missing faces on solid models)	(score: 3)	4
- -	Data is migrated only 'as-needed' (i.e. due to cost, effort and disruption ,cannot justify migration of all legacy data to new system)	(score: 0)	5

BOM hierarchy incorrect was only noted by two members, and was not mentioned by the solution providers. *Data intelligence lost* was noted by members, but not solution providers.

While *Data and file corruption* was not cited by Members as a Top 5 causal factor, it was by solution providers.

#1 Advanced features imbedded in native data structures

Current state

Member perspective: The impact of proprietary features and data formats is that they inhibit interoperability and increase costs. The impacts include additional costs for translation, validation and manual interventions, downtime, additional licenses, additional system interfaces, and additional custom code. Proprietary features can inhibit upgrades if they are not understood upfront.

Solution provider perspective: The worst-case impact is that data typically has to be re-mastered. Major issues can occur when there is not an upgrade path, or the features are not understood.

Trending over time

Member perspective:

Past 10 years: The addition of features in software has added complexity and caused increases in cost.

Next 5 years: The costs should stabilize as data moves out of the CAD model into systems engineering layer.

Solution provider perspective:

Past 10 years: The costs have been increasing over the past 10 years.

Next 5 years: The costs may decrease over the next 5 years.

Company vs provider control

Member perspective: If standards or a standardized approach can be adopted, then costs and benefits can improve, so it is primarily the solution providers in control.

Solution provider perspective: The solution providers have the control.

CIMdata observations

Proprietary features add value and enable the solution providers to differentiate their products. An alternative is to control which proprietary features can be used within an organization and only use features that can be reasonably used up or down stream. Regarding systems engineering, if standardized or commercial components are used, then yes, systems engineering will help, but that does not solve the geometric interoperability problem.

#2 BOM hierarchy incorrect (i.e., multi-level becomes single level, quantities incorrect)

Current state

Member perspective: Causes of issues include complex structures, varied data ownership, and variations in business rules from program to program and function to function within a company. Data cleanliness and structure variations also cause issues. Key issues include tools to: flatten/indent BOM, legacy data validation (also done manually), and migration from drawing to item based products.

This is a costly and time-consuming issue.

Solution provider perspective: <no response>

Trending over time

Member perspective: System consolidation and leveraging legacy data will reduce development costs, but maintenance cost will increase. Tribal knowledge is a concern due to the retirement of people who developed the complex custom solutions. The cost to understand what was done will increase as will the cost of mistakes from changes made to complex code without a complete understanding.

Custom solutions will be replaced by modern eBOM/mBOM/sBOM solutions reducing costs in the mid to long-term.

Solution provider perspective: <no response>

Company vs provider control

Member perspective: The responsibility is shared. Solution providers can support better BOM comparison, transformation & reconciliation, and an End-to-End BOM process across the enterprise. Members need to standardize data and processes so the software providers can more easily support their customers.

Solution provider perspective: <no response>

CIMdata Observations.

The *BOM hierarchy incorrect* was ranked by only two of four members, and was not mentioned by the solution providers. This topic may need further investigation and definition by the Members to enable productive discussion and joint resolution with the software providers.

#3 Data authoring application is no longer available

Current state

Member perspective: Many different systems have been used (CADDS5, CCD, Catia v4, v5, UG, NX, etc.) Data may not be upward compatible, or newer algorithms generate different shapes or even different models. The impacts include; expensive data migration and data validation costs, and the effort of labor intensive, manual cleanup. Wiring harnesses are an example of data that had no migration path.

Solution provider perspective: This is a big issue for CAD authoring tools when legacy data is left in the last major version. Skills to operate the old application become an issue. Keeping data in legacy formats adds significant cost and flexibility challenges when changes are required or reuse is possible. Rework requirements limit effectiveness of bulk translations. Lightweight formats will help going forward.

Trending over time

Member perspective: Reduction in legacy CAD environments and improved 3D standards will help. PMI information will be the next big issue.

Solution provider perspective: Costs will stay high as CAD continues to add capabilities. Better lightweight formats may help as will a LOTAR strategy.

Company vs provider control

Member perspective: Software vendors control the technology, but A&D companies need to set requirements and validate that the software performs to the requirements.

Solution provider perspective: 100% Upgrades to latest version must be supported. A&D companies need to define requirements and validate data.

CIMdata observations

The members and solution providers are well aligned regarding this item. The issue is linked to the solution provider's software progression strategy, i.e., do they pursue a continuous or discontinuous innovation strategy. Lightweight, standards-based models derived from authoring tools and a LOTAR strategy are potentially effective mitigation methods.

#4 Data intelligence is lost: a) feature data or b) object relationships

Current state

Member perspective: Companies do a lot of testing to validate data and minimize information loss. Standards based translators lose information. The impact is high cost due to rework, downtime, and validation. As much as 60-70% of translations have issues.

Solution provider perspective: The expectation of data intelligence loss during translation or migration for a system upgrade is a barrier to upgrading forcing customers to remain on old versions. By not migrating all data, the issues are just delayed until the

future. On demand migration impacts costs and schedule. Custom tools are required for validation, and manual effort is required to cleanse data.

Trending over time

Member perspective: The costs increased over previous 10 years, hopefully will stabilize over next 5 years based on CAD maturity and consolidation.

Solution provider perspective: The risks and costs with CAD data were high enough that CAD data was left in the last major release. Current solutions seem to be more upgradable and 3Dsearch and lightweight data will help reuse.

Company vs provider control

Member perspective: The issue is primarily the solution provider's responsibility, but A&D companies need to standardize use cases and be cautious about which capabilities to leverage.

Solution provider perspective: Solution providers need to guarantee upgrades of CAD data within their solutions without loss. STEP needs to be more fully supported. A&D companies need to implement LOTAR and drive standards adoption.

CIMdata observations

The solution providers and members are philosophically on the same page, but it has not worked out well in the real world. Standards, visualization formats, and LOTAR seem to be the trends to be pursued.

#5 Data or metadata inconsistent, violate creation standards

Current state

Member perspective: Data is lost when migrating, thereby creating a barrier to upgrading. This leads to high costs for new projects especially when data reuse is planned. Interoperability, data distribution and problematic data migration are all impacts. A simple example is non-readable characters in Unix to be displayed in Windows version after migration.

Solution provider perspective: Variations in the data model occur when multiple solution instances are used making migration difficult. Data and metadata are replicated in multiple solutions. Data is inconsistent for technical reasons but also because the master is unclear when data is replicated to multiple solutions.

Trending over time

Member perspective: Data complexity and higher volume increased costs over past 10 years. The costs should level off due to better technology, data quality and governance.

Solution provider perspective: Business data model misalignment and data replication caused many of the past issues. Increased use of common data models and a better replication/distribution architecture will improve cost, capability, and flexibility.

Company vs provider control

Member perspective: This is primarily a discipline issue with the members. The solution needs to enforce data compliance with design standards.

Solution provider perspective: The solution providers need to ensure data model upward compatibility.

CIMdata observations

It seems that the members and the solution providers are looking at the same problem and extracting two different root causes. Interestingly each party is accepting responsibility. Members see the cause as a matter of data entry discipline. Solution providers see the cause as a matter of data model continuity when upgrading a PLM solution. Both perspectives are valid and need to be addressed.

Master Data Management needs to be properly implemented to ensure data quality.

Mitigation Methods

The #1 member ranked mitigation method *Supply chain uses standard authoring applications* clearly tops the field. The member score of 16 score indicates moderate agreement between the members on the ranking of this item. There was fair alignment of priorities between the members and their solution providers, with one exception.

Member Rank	Mitigation Method	Member Score	SP & SI Rank
1	Supply chain uses standard authoring applications	(score: 16)	1
2	Partnership with software provider to influence product	(score: 13)	2
3	Virtual or physical legacy system implementations	(score: 12)	- -
4	Comprehensive data-aging plan	(score: 9)	3
5	Single provider PLM software procurement policy	(score: 8)	- -
- -	Use validation tools within data creation process to enforce standards	(score: 6)	5
- -	Strict enforcement of OOTB application implementations	(score: 0)	4

The only significant difference is that the solution providers rank *Strict enforcement of OOTB application implementations* within their top 5 mitigation methods. Currently members hold the view that OOTB implementations cannot meet their business requirements and that heavy customization is necessary for competitive advantage.

#1 Supply chain uses standard authoring applications

Current state

Member perspective: It has been successful so far but limits supply chain to large partners that can support the overhead. The impacts include:

1) Positive: more consistent data integrity, with less integration required
2) Negative: supply chain cost, resistance to change from what is currently used
3) Long term: need to make standards based data exchange work to reduce costs and ensure broad interoperability

Solution provider perspective: The use of mandated tools is increasing due to "risk sharing". This helps the A&D OEM, but increases supplier cost and complexity. Ultimately the cost is passed back to the A&D OEM. The impacts include:

1) The OEM complexity is minimized.
2) Blockers include immature data exchange procedures, and variation across the OEMs in both format and protocol.
3) There is a lack of maturity and confidence for the standards based formats and protocols

Trending over time

Member perspective:

1) Applied in the past
2) Applied now
3) It will be applied in the future

Solution provider perspective:

1) Applied in the past
2) Applied now
3) It will be applied in the future

Company vs provider control

Member perspective: A&D Companies should lead as a group, so far acting as individuals has not been effective.

Solution provider perspective: The responsibility is equal, solution providers need to implement exchange standards and A&D Companies need to use them.

CIMdata observations

Again, leveraging standards is recognized as the long-term solution. The A&D Action Group needs to identify gaps limiting adoption and work with other A&D Companies and software providers to close those gaps.

#2 Partnership with software providers to influence product

Current state

Member perspective: It is applied on the primary applications, usually using requirements definitions. The better the requirements the better the impact. A key blocker is for the member to understand what the solution provider is capable of developing and implementing.

To date the influence is perceived to be low. Requests are not implemented due to narrow focus or high cost of development.

Solution provider perspective: Collaboration between A&D companies and solution providers remains an important process. Influencing solution provider roadmaps to minimize the migration expense is an important opportunity for A&D companies.

While collaboration between A&D companies and solution providers is routine, this has not prevent major challenges in migrating data from legacy PLM environments. The cost of this migration is often significant and can delay implementation of new PLM capabilities. Solution providers have extended their products to address specific A&D company migration needs.

Trending over time

Member perspective:

1) Applied in the past
2) Applied now
3) It will be applied in the future

Solution provider perspective:

1) Applied in the past
2) Applied now
3) It will be applied in the future

Company vs provider control

Member perspective: The members don't feel they have had much influence.

Solution provider perspective: Solution providers need to ensure openness, and provide robust migration tools. A&D companies need to minimize customization that will impede future migrations.

CIMdata observations

Will industry focused solutions address this issue? What can be done to improve the adoption of Standards-based data exchange?

#3 Virtual or physical legacy system implementations

Current state

Member perspective: Most members are using virtualization, but **i**t makes it difficult for COTS vendors to provide support as well as making it difficult to migrate to upgraded versions and harmonize.

In general, virtualization is not a good strategy, due to instabilities that are difficult to identify. The other consideration is that the high cost to maintain support of the older implementations remains.

Solution provider perspective: <no response>

Trending over time

Member perspective:

1) Applied in the past
2) Applied now
3) It will be applied in the future

Solution provider perspective: <no response>

Company vs provider control

Member perspective: It is the A&D Company's choice. It gives the solution providers way too much power, so this option is self-defeating to the enterprise due to the continuation of legacy solutions.

Solution provider perspective: <no response>

CIMdata observations

This solution may become more necessary as architectures shift to the cloud. Virtual instances will be easier to maintain than physical instances. The most complete solution is to migrate all important data and retire the legacy solutions.

#4 Comprehensive data-aging plan

Current state

Member perspective: A data aging plan is becoming critical. The product lifetime is expanding. New planes are often derivatives of existing designs instead of brand new programs. This expands the lifetime of the data.

LOTAR initiatives exist, but are incomplete. They have been done using expensive customizations in the past. One member is having a positive impact with current CAD software, but proprietary formats are expensive to support. The key issue is to "know your data".

Solution provider perspective: The A&D industry has pursued LOTAR and data aging plan initiatives for several years. Standards have matured but A&D companies must continue to engage and develop them further.

Trending over time

Member perspective:

1) Applied in the past
2) Applied now
3) It will be applied in the future

Solution provider perspective: LOTAR needs to be better defined within context of standards

Company vs provider control

Member perspective: It is a shared responsibility, but the members should lead.

Solution provider perspective: It is a shared responsibility. Solution providers can support and comply with the latest standards (e.g.: AP242, JT) as well as continue active participation in LOTAR workgroups. A&D companies must setup a strategic and operational organization in charge of data migration and data warehouse activities.

CIMdata observations

The problem appears to be recognized and well understood. The key issue is how to make it happen faster.

#5 Single provider PLM software procurement policy

Current state

Member perspective: Common software reduces the A&D Company's direct cost and complexity but shifts it to the supply chain. The pressures put on the solution providers make it difficult to support the rest of their customer base. A&D Companies have tried to avoid being software developers, but the true impact of this will be seen in the next major upgrade. The costs to customize to meet our requirements are still too high.

Solution provider perspective: <no response>

Trending over time

Member perspective:

1) Applied in the past
2) Applied now
3) It will be applied in the future

Solution provider perspective: <no response>

Company vs provider control

Member perspective: The customer has minimal power to influence solution provider.

Solution provider perspective: <no response>

CIMdata observations

Obviously solution providers prefer to own the whole account, but, it is high risk for them, in this winner take all competition. There are no case studies showing that more interoperable solutions are replaced more often. Conversely if a solution is easy to interoperate with, niche solutions can be more easily added to bridge gaps, without replacing the main solution.

OBSERVATIONS AND FINDINGS

This section documents summary observations and findings as derived from analysis of the survey results and follow-on interviews.

PLM Obsolescence Management Model

The primary goal of this first phase research was to identify the top causal factors and mitigation methods related to the cost of technology refresh and risk of product data loss. To that end, the survey asked Members to provide input for each category independently. To explore interdependencies and correlations between causal factors and mitigation methods would have complicated and extended the survey to an impractical degree.

Even though interdependencies and correlations were beyond the scope of the survey, it was possible to extract some insights through analysis of the survey responses and follow on interviews. A few significant relationships and correlations, as illustrated with arrows in Figure 2, were derived from the Members' descriptions and current state assessments.

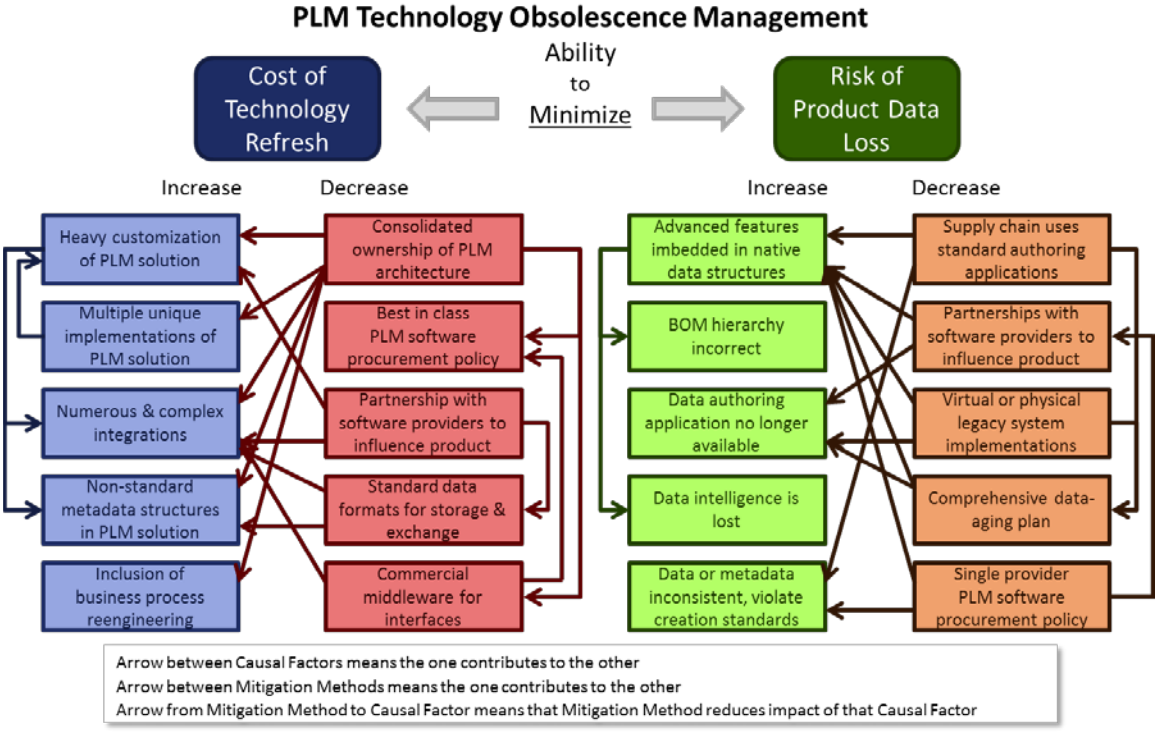

Figure 2 – Interdependencies and Correlations between Causal Factors and Mitigation Methods within the PLM Obsolescence Management Model

Interdependencies between Causal Factors and Mitigation Methods

In Figure 2, causal factors and mitigation methods are shown in rank order. Interdependencies, where one causal factor can contribute to another or one mitigation method can reinforce another are indicated with arrows. One-way arrows pointing to the left from mitigation methods indicate causal factors that they can reduce.

It is significant that the top rated causal factors and mitigation methods have the most outgoing arrows. This reinforces the high ratings assigned by the Members.

It is also significant that some causal factors and some mitigation methods show no correlations. These instances indicate gaps in the current model.

Heavy customization and multiple unique implementations are primary cost drivers

Two primary factors drive the cost of technology refresh. They are the amount of customization allowed and the number of unique instances or implementations allowed.

There are many reasons why an OEM would opt for unique, disparate implementations such as: programmatic or divisional control of funding; non-uniform business processes, applications, data standards or infrastructure; or strategy that each new implementation will incorporate the next round of business improvement, but previous implementations will remain unchanged.

Heavy customization is a natural complement to multiple unique implementations, but can also be motivated by other considerations such as: desire to minimize disruption to the workforce by mimicking current business processes and tools; or belief that competitive advantage is achieved through heavy use of non-standard processes that require heavy modification of commercially available tools. In addition, many integrations to legacy systems are developed in house as customizations and can be quite complex due to transformations required to move data and metadata between systems.

As shown in Figure 2, these are two major factors driving the cost of technology refresh. In addition, they contribute to two other major factors that drive cost.

Consolidated ownership of PLM architecture is the primary cost mitigator

As illustrated in Figure 2, consolidated ownership of PLM architecture can potentially mitigate the effect of each major cost factor. Consolidated ownership means that all the organizations responsible for the various PLM solution elements operate within a single governance structure. That would provide a mechanism for definition and enforcement of policy to reduce the amount of customization, increase implementation uniformity, reduce the number and complexity of integrations, and increase standardization of metadata representations and data structures. To the extent that such policies are established and enforced the effect on several causal factors can be large.

Advanced features in authoring applications pose greatest risk of data loss

Advanced features imbedded in native data structures is the highest ranked causal factor for risk of product data loss. As shown in Figure 2, it is also a root cause contributing to two other major causal factors. An important aspect of imbedded features is that its impact is both short term and long term. Data intelligence is lost when a design file is transferred to an application that cannot fully interpret the file content. In the near term, this can be mitigated by requiring all entities in the design chain to use the same authoring application. However, this is an impractical solution over the long term.

Standard application usage in supply chain is primary risk mitigator

As just mentioned above, requiring all entities in the supply chain to use a standard authoring application is an effective remedy to loss of data intelligence resulting from imbedded features in the application. As shown in Figure 2, this #1 rated mitigation method is in direct correspondence to the #1 rated causal factor.

Current State Assessment

In reviewing the Member and Supplier assessments of the current state, the following observations became apparent.

Contradiction between Best in Class and Single Provider as mitigation methods

Several Members named *Best in class PLM software procurement policy* as a mitigation method to reduce cost of technology refresh. This policy conflicts directly with *Single provider PLM software procurement* also named by Members as a mitigation method to reduce the risk of product data loss. Despite probing during follow on interviews this apparent contradiction remains unexplained.

As shown in Figure 2, *Best in class PLM software procurement policy* does not correlate with any of the Top Five Causal Factors, highlighting the ambiguity of this mitigation method. In fact, many in industry, including CIMdata consider “best in class procurement policy” to be a cause of increased technology refresh cost.

Clearly best in class applications are more effective for the specific business processes that they support. In addition, a best in class procurement policy may increase competition and, thereby, reduce procurement cost. However, the integration of data and process flows between multiple applications is more complex and expensive to implement and to maintain during technology upgrades.

Surprising that out-of-the-box (OOTB) did not make the Top Five list

With *Heavy customization* ranked as the #1 contributor to the high cost of technology refresh, it is surprising that enforcement of out-of-the-box (OOTB) did not rank in the Top Five. In fact, *Strict enforcement of OOTB application implementations* at #9 just made the top ten.

Enforcement of OOTB is one element of *Consolidated ownership of enterprise architecture*. However, the fact that enforcement of OOTB is not a high-ranking

countermeasure on its own indicates ambivalence in Members' attitude toward customization.

Two views of business process reengineering

The prevalent view expressed by the Members regarding business process reengineering is that it can provide significant near term benefits for competitive differentiation, but the cost, effort and disruption of changing process and technology at the same time can be very high and the level of disruption and natural resistance to change elevate the risk of project failure.

This perspective completely overlooks the potential of business process reengineering to reduce complexity and cost of technical implementation and technology refresh by aligning the business processes closer to the standard OOTB solution. From this perspective business process reengineering is not a driver of cost but rather a mitigation method to reduce cost of technology refresh.

Some data loss mitigation methods address near term, some address long term

Managing the risk of product data loss is complicated by the fact that data loss can be partial and it can occur over a time range of near to long term. Mitigation methods can target different timeframes and can have different objectives for how much of the data content is protected from loss. Methods targeting the near term attempt to protect all data content to enable complete reuse. Methods targeting the long term have narrower objectives for data preservation, often sacrificing intelligence within the files and preserving only access to the geometric shape, a rendering of drawing data, and metadata.

Referring to Figure 2, some of the top ranked mitigation methods address risks in the near term – *Supply chain uses standard authoring applications*, and *Single provider PLM software procurement*. Others address risks in the long term – *Virtual or physical legacy system implementations*, and *Comprehensive data-aging plan*. One addresses both near and long term – *Partnership with solution providers to influence product*.

Partnership with software providers is a good idea that doesn't work well

Partnership with software providers to influence product ranks #3 as method to mitigate cost of technology refresh and #2 as method to mitigate risk of data loss. All Members consider this important; all Members invest considerable effort; and all Members are dissatisfied with the results. Carefully articulated requirements and policy promoted by a broader representation from the A&D industry may prove more effective in motivating and directing solution provider investments.

The two software providers and two systems integrators who responded to the survey expressed views aligned with the Members on this topic. Dassault Systemes, who, after many requests, declined to participate in the research, perhaps does not consider partnership with its customers as important as do their competitors.

Good ideas for data loss mitigation that don't work well – yet

Some of the methods for mitigating risk of data loss over the long-term hold promise but have shortcomings that undercut their effectiveness.

Virtual or physical legacy system implementations

Most Members use virtual or physical legacy system implementations to maintain access to legacy data, but these present several significant operational difficulties. Each production implementation of the authoring application, current and historical, must be replicated exactly. The member experience is that the virtual implementation has issues when compared with original production implementation that are difficult to solve. In addition, the legacy environments require a continual overhead investment for upgrading and testing the implementations. Over time, implementation and support of virtual legacy environments may become more automated, but the utility of legacy data for reuse will still be dependent on the effectiveness of cross version data migration methods and tools. Virtual legacy environments should offer complete access to data for reference, investigation, and even modification in the data's original context but, this has not been proven in practice.

Comprehensive data aging plan

At the heart of any data aging plan is Long Term Archiving or LOTAR. PLM data converted and stored in LOTAR format will persist reliably over the long term, minimizing the risk of data loss and supporting many different use cases. However, some information is lost in the conversion since LOTAR leverages standard data structures and, therefore, does not support all proprietary data structures used in a proprietary PLM solution. Over time, LOTAR will become more comprehensive and industry may advocate with greater success for standards based authoring application data formats and structures.

Unreconciled conflict between innovation, cost and risk

It is apparent from Member assessments of the current state that they have not reconciled their view that innovation is critical to business success with their view that the cost and risk of technology refresh are far too high. For some Members the priority is clear: first, full support for innovation (e.g. heavy customization and unique implementations of competitively differentiating business processes); second, aggressive pursuit of measures to reduce cost and risk without compromising innovation. This approach inevitably results in rapidly escalating maintenance and technology refresh costs with the unintended consequence of reducing resources available for innovation. Longer term, a balanced approach based on cost-benefit analysis will be needed to contain cost and increase the level of resource available for innovation.

Differences between Members and solution provider perspectives

Overall, the views of the two systems integrators and the two software providers who responded to the survey align closely with those expressed by the Members. However, there were a few significant differences.

Ranked highly by solution providers but not by the Members

Solution providers ranked *Organizational resistance to change* as #4 causal factor of high cost while the Members ranked it #10.

Solution providers ranked *Data or metadata inconsistent, violate creation standards* as #1 causal factor of data loss risk while the Members ranked it #5.

Solution providers ranked *Single provider PLM software procurement policy* as #3 mitigation method for high cost while the Members ranked it #8.

Solution providers ranked *Strict enforcement of OOTB application implementations* as #4 mitigation method for high cost while the Members ranked it #9.

Solution providers ranked *Strict enforcement of OOTB application implementations* as #4 mitigation method for data loss risk while it was unranked by the Members.

Ranked highly by the Members but not by solution providers

Members ranked *Best in class PLM software procurement policy* as #2 mitigation method for high cost while the solution providers ranked it #7.

Members ranked *Use commercial middleware for integrations* as #5 mitigation method for high cost while the solution providers ranked it #10.

Members ranked *BOM hierarchy incorrect* as #2 causal factor of data loss risk while the solution providers ranked it #7.

Members ranked *Virtual or physical legacy system implementations* as #3 mitigation method for data loss risk while it was unranked by the solution providers.

CONCLUSIONS

The results of this research and analysis support the following conclusions.

Causes of high cost and risk of data loss are primarily technology based, but mitigation methods are primarily policy and process based

Most of the causal factors are described in technical terms. Heavy customization, disparate implementations, numerous and complex integrations and most of the others describe characteristics of the software as received from the provider or of the technical solution as implemented.

In contrast, most of the mitigation methods are described in terms of governance processes or policy decisions. Consolidated ownership of PLM architecture, partnership with software providers, standard authoring applications throughout the supply chain and

several others prescribe policy or process to specify characteristics of the software or control the technical solution implementations.

Standards, especially in relation to LOTAR, will play an increasingly important role in mitigating risk of data loss

Some of the major mitigation methods involve the development and application of standards.

For long term data retention, a comprehensive data aging plan is critical to mitigating the risk of product data loss. Advancing the development and then the adoption of data storage standards will greatly enhance the value of the archived design data.

For near and mid-term data reuse, promoting the adoption of STEP for PLM information storage and exchange, and JT and 3DPDF for real time collaboration processes and data exchange not only facilitates these processes, but also reduces the cost, effort and disruption of data cleansing and migration during a PLM system upgrade. Reducing the effort and disruption mitigates the risk of data loss due to incomplete data migration.

Members have the primary role in mitigation of cost and risk of technology refresh

Governance processes and policy decisions are within each Member's control. Therefore, Members can assume the primary role in mitigating their cost and risk of data loss associated with a technology refresh. That is not to say that execution of this control will be easy. The greatest challenge will be cultural resistance to extending policy or governance beyond customary bounds of authority. This resistance is typically very powerful. In fact, it is often the root cause underlying many of the causal factors ranked in the Top Five by Members.

Consolidated ownership of PLM architecture offers great potential for cost reduction

Consolidated ownership of PLM architecture means that all the organizations responsible for the various PLM solution elements – business functions focused on engineering, manufacturing, and service, as well as IT functions focused on applications, networks, servers, and desktop – operate within a single governance structure.

This is the #1 ranked mitigation method for high cost. With this ranking, Members correctly assessed the potential impact of establishing a mechanism for definition and enforcement of policy to reduce the amount of customization, increase implementation uniformity, reduce the number and complexity of integrations, and increase standardization of metadata representations and data structures.

Solution providers can play a significant role in mitigation of cost and risk, but will need clear communication and strong financial pressure from their customer base

PLM software providers have the means to affect several causal factors and enable mitigation methods of cost and risk through the design strategies and development priorities they set for their application systems. Topics of value include new A&D functionality and process support, storage and exchange standards support, version migration tools, commercial application interfaces and others.

In their responses, the suppliers claim to value partnership with their A&D customers, but their actions do not support this claim. They rationalize their inaction with claims that their A&D customers do not communicate needs clearly and consistently, and that the customers who do communicate do not represent sufficient buying power to drive their investment priorities. It is the A&D PLM Action Group's mission to counter this rationale by providing clear communication and strong financial pressure from a broad A&D customer base.

RECOMMENDATIONS

Members should consider additional research to explore in greater depth a subset of causal factors and mitigation methods identified in this project. Goals for this research would include:

- Understand more deeply the causal factors contributing to the negative consequences of PLM technology obsolescence
- Understand strategies and tactics of industrial leaders for managing obsolescence (e.g., Lean and Agile methodologies)
- Understand the potential of financial models for management of PLM technology upgrades
- Understand the potential impact of international standards related to product data including STEP, JT and PDF and how they can be used to mitigate the negative impact of PLM technology obsolescence
- Understand the industry trends that will have a positive impact on PLM technology obsolescence management
- Develop policy, process and technology guidelines and requirements to minimize the negative impact of PLM technology obsolescence while keeping PLM solutions refreshed and up to date

CIMdata would prepare alternative Phase 2 research project plans for Member review and prioritization.

The selected project plan for Phase 2 research would be included in the list of research projects under consideration by the Group for funding in 2015.

About CIMdata

CIMdata, a leading 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 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 certification programs, seminars, and conferences worldwide. CIMdata serves clients around the world from offices in North America, Europe, and Asia-Pacific.

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