PLM Technology Obsolescence Management

Problem Statement, Desired State and Requirements

A&D PAG Position Paper (AD PAG PP03.1)

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Revision Record

Revision	Date	Description
03.0	Feb 2017	Initial Release
03.1	Nov 2017	Revision in response to PLM software provider review, and expansion of requirements.

PLM Technology Obsolescence Management

Introduction

Over the past few years, a new conversation has been taking place within the aerospace and defense community arising from a growing recognition that certain persistent pain points—points of friction, complexity or instability that erode the productivity and quality of product information flow through aircraft and defense systems programs and inflate the cost of systems sustainment—are common across the industry. In March 2016, executives from the Aerospace & Defense PLM Action Group (A&D PAG) member companies met with the intent that informal discussions of PLM-related issues would lead to agreement on common objectives, requirements, and plans for remediation of their common PLM pain points.

Their discussion resulted in agreement of the member executives to jointly sponsor and staff a select set of projects, each chartered to define objectives, requirements, and a roadmap for eliminating or significantly reducing a key inhibitor to the value potential of PLM. The topic addressed by this special project is *PLM Technology Obsolescence Management*. The scope of the project team's activity was to define top-level objectives and requirements for an industry standards-based PLM architecture for obsolescence resilient solutions that will enable global collaboration within a multi-vendor PLM environment. While we understand that PLM improvement requires people, process, and technology all change, the focus of this paper is only on technology. Process improvement and organizational change are not within scope.

This document presents a set of requirements for Obsolescence Management along with the business context within which they were derived. First, the problem, or "pain point," is described, including a characterization of the current negative business impacts. This is followed by a description of the desired future state, including characterization of the resultant business performance improvements. Within this context, the business improvement objectives and a set of derived requirements are put forth. These requirements specify conditions that, if met, will achieve the stated objectives, enabling the desired state and business improvement. The final section lays out the response requested from the PLM software providers and other relevant entities within the PLM ecosystem.

Within version 3.1 we have incorporated revision in response to feedback from invited document reviews performed by the PLM software providers.

Purpose of this Document

The intent of this document is to provide the basis for productive dialogue within the A&D PLM community. Initial distribution will be to a select set of PLM software providers with a request for response and support. However, this is only the first in what will be a series of position papers that address the topic in ever increasing detail, ultimately resulting in a detailed requirements statement.

Through this progression, it is the intent of the A&D PAG members to engage the broader PLM community in dialogue.

Problem Statement

PLM Technology Obsolescence Management is defined as the ability of an aerospace & defense 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.

Context

For the past two years, the A&D PLM Action Group has been performing research on PLM related areas that have large impacts on the creation, maintenance, and dissemination of product related information. A key area identified early as a major topic of concern was managing obsolescence of both data and data management solutions.

The data for a typical airplane includes:

- Several hundred thousand unique physical components
- Over one million component instances
- BOM's including CAD assemblies, Requirements, Software, As-Designed, As-Planned, As-Manufactured, As-Delivered, As-Maintained
- Documentation including product and manufacturing process documentation
- Change management data
- Regulatory certification data
- Millions of lines of software code
- Complex relationships between data elements

In addition, the design cycle for an A&D program can take 5 to 10 years with thousands of people acting as authors of data and tens of thousands acting as consumers of data. Hundreds or even thousands of software applications from many solution providers are used by authors to create and maintain the data.

Scenarios

Data Retention Through Program Life

A&D products, that is aircraft and many weapon systems, have a long lifecycle that can span 30 to 50 years or more, and have large volumes of data assets that are costly to migrate to new PLM technology platforms. Because of these characteristics, A&D companies commonly choose to retain product data in the format of the PLM solution within which they were originally created and stored. The strength of this practice is that it maintains data integrity and PLM solution performance through the life of the program. A major weakness is that advancement of PLM technology only occurs at the beginning of a new program, not within the lifecycle of any given program.

Different PLM Solutions Between Programs

Almost always within aerospace companies and often within defense companies, new programs reuse product data from previous programs. It is frequently the case that these programs utilize different PLM technology platforms, or at minimum different release levels of PLM software and different extensions and customizations within their enabling PLM solutions. Under these conditions, data reuse across programs requires new integrations and/or data migrations between PLM solutions, supported by new administrative processes to assure synchronization of the program data repositories and access to the data by various PLM technologies.

PLM Platform Generational Changes

Occasionally a PLM software provider will decide that one of their platform architectures requires a generation change (e.g., CATIA V4 to V5, Windchill 6 to 8 to 10). When this happens, their current customers must re-implement their current PLM solution on the new architecture. The cost and disruption to the business just to reach parity with the previous implementation is substantial.

Business Consequences

Data Retention Through Program Life

Negative consequences of retaining product data in the format in which it was generated through the life of a program include:

- It is difficult to leverage IT technology improvements, such as the recent example of the inability to leverage cloud related technology or the older example of the inability to decommission Unix workstations long after Windows PCs were the norm in other industries.
- Over the program lifecycle, the user interface and technology capabilities fall significantly behind the state of the art, reducing productivity and causing user dissatisfaction.
- The cost of long term data archiving and the risk of data loss increases over time, especially as more and more commercial elements of the originating PLM environment are no longer supported by the technology provider and as personnel with detailed knowledge of the solution implementation leave the company.

Different PLM Solutions Between Programs

Negative consequences from using different PLM platforms between programs include:

- Leveraging legacy program data within a newer program that utilizes a different PLM solution is difficult. Since the originating program is still running, data must be copied from the original PLM solution to the new PLM solution leading to unclear ownership of master data and more complex data maintenance processes.
- Since legacy programs remain on their original PLM solution, each new PLM solution implementation results in one additional PLM solution that the A&D company must maintain. Over the decades, this repeated pattern has resulted in escalating maintenance costs with little net benefit to the company and reduction of funds available for investment in solutions for business improvement.

PLM Platform Generational Changes

Negative consequences of a PLM platform architecture generational change include:

- The upgrade requires major investment to migrate customizations, interfaces, and data to the new PLM platform.
- The user community must undergo retraining and will be subjected to a learning curve resulting in lower productivity for an extended period, all for no net benefit.
- The cost and disruption of data migration will be substantial.
- The risk of loss of data assets (full or partial) is substantial.
- Reluctance to upgrade due to anticipation of the consequences described above results in a vicious cycle of investment in legacy solutions, increasing the eventual cost of upgrade even more.

Causal Analysis

In 2015, A&D PLM Action Group sponsored research produced a model, shown in Figure 1, that identified the most significant causal factors contributing to and mitigation methods for managing the negative consequences of PLM technology obsolescence. In addition, relationships among causal factors and mitigation methods were identified.

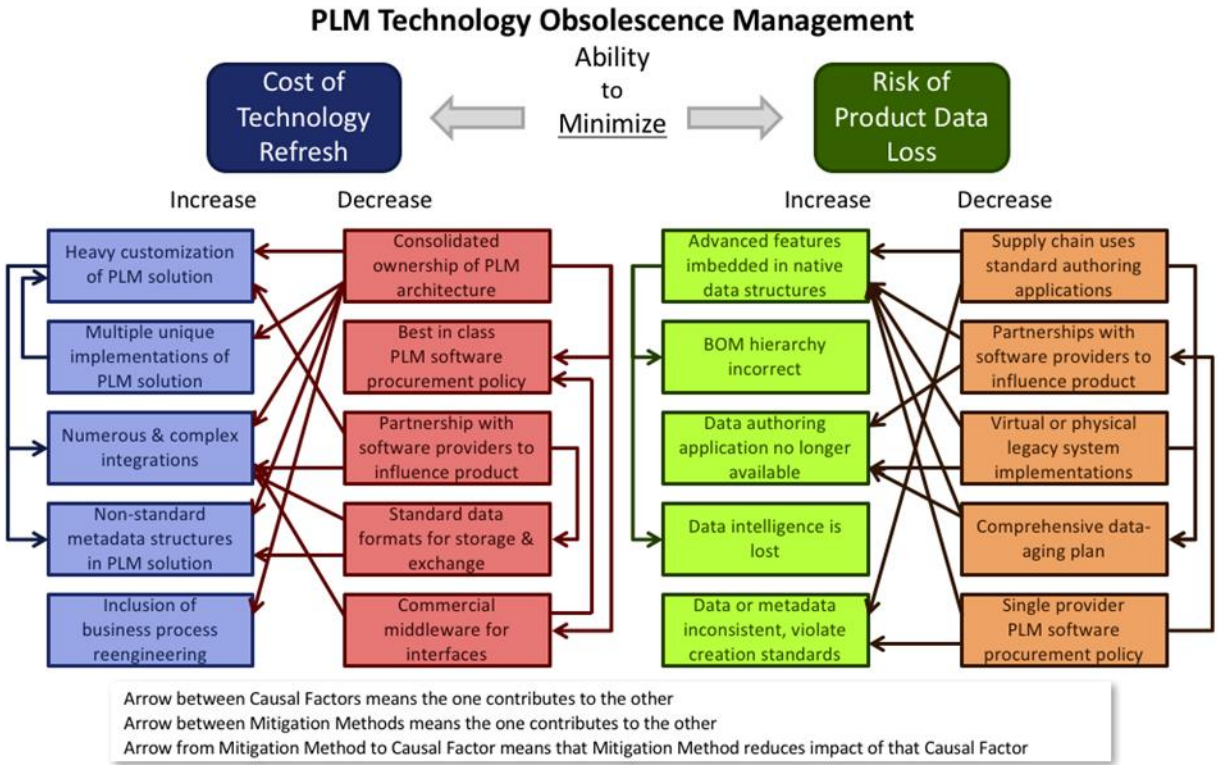

Figure 1—Elements and Relationships within the PLM Technology Obsolescence Management Model

The Ishikawa diagram shown in Figure 2 presents results of a more recent analysis that groups those causal factors that increase obsolescence management cost and risk into organization, process, technology, and information domains.

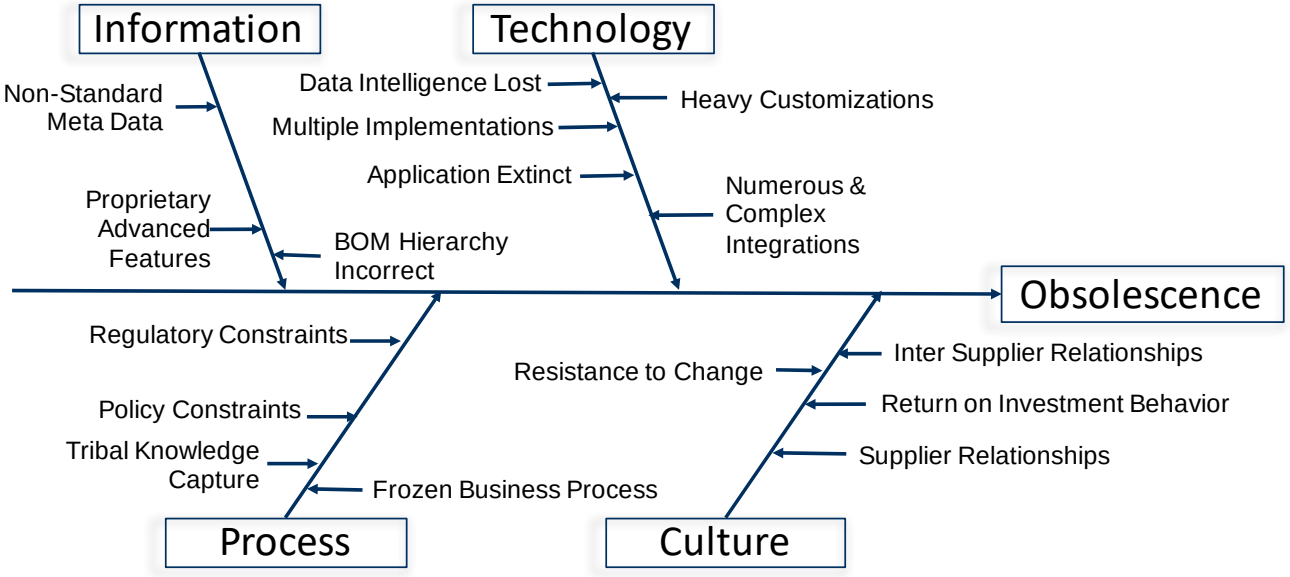

Figure 2–Ishikawa Diagram Showing Causal Factors that Drive PLM Technology Obsolescence Management Cost and Risk

PLM technology obsolescence is most closely related to the Information and Technology domains (data and data management) in Figure 2. Each of the elements grouped into these domains is described briefly below.[1]

BOM Hierarchy Incorrect—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 *Proprietary Advanced Features* imbedded in application-specific data structures.

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.

Non-standard Metadata—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.

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.

[1] CIMdata, Inc. *PLM Obsolescence Management Phase 1 Research Report, Initial Model and Current State Assessment*. Research sponsored by Aerospace & Defense PLM Action Group. January 2015.

Proprietary Advanced Features—For competitive and performance reasons PLM software providers implement proprietary data structures within their products. Often 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.

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.

Data Intelligence Lost—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 *Proprietary Advanced Features* imbedded in native data structures.

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.

Multiple Implementations—Multiple PLM solutions 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.

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.

Application Extinct—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 providing migration methods or tools.

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.

Heavy Customization—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.

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.

Numerous and Complex Integrations—PLM solutions are typically made up of many different software applications linked together to create and manage the product definition over its lifecycle. Within the PLM solution, a product definition management (PDM) application captures and coordinates the information from the different software applications used to define and modify the product definition. Integrations are created between the PDM solution and these authoring applications. Additional integrations are created to support sharing 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.

Some integrations, especially between authoring applications and the PDM 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.

Objectives

PLM Technology Obsolescence Management 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.

The overall goal of this project is to define a desired future state, business improvement objectives, and a set of derived requirements for PLM solution providers that, if implemented, will minimize the pain associated with managing and reusing data in long lifecycle products.

Business improvement objectives defined by the project team are:

1. Define a high level architectural pattern for PLM in A&D
2. Agree on top-level requirements for:
   - A PLM architecture based on industry standards that define behavior and interfaces
   - Obsolescence resilient solutions enabling global collaboration in a multi-vendor environment
3. Reach strong shared targets
   - Minimize the obsolescence related cost for PLM over the A&D product lifecycle
   - Enable continued use of knowledge and data from A&D programs
   - Enable process integration along product lifecycle phases

Desired State

Context

The project team conducted a series of workshops and discussions to analyze several alternative conceptual PLM architectures. The team selected the alternative that best aligned with their individual company IT infrastructure strategies and requirements while minimizing PLM technology obsolescence management costs and risk.

Architectural Choices

The project team considered several alternative architecture patterns and frameworks during the analysis phase of this project. Alternatives that were considered include are shown in Figure 3 and described below:

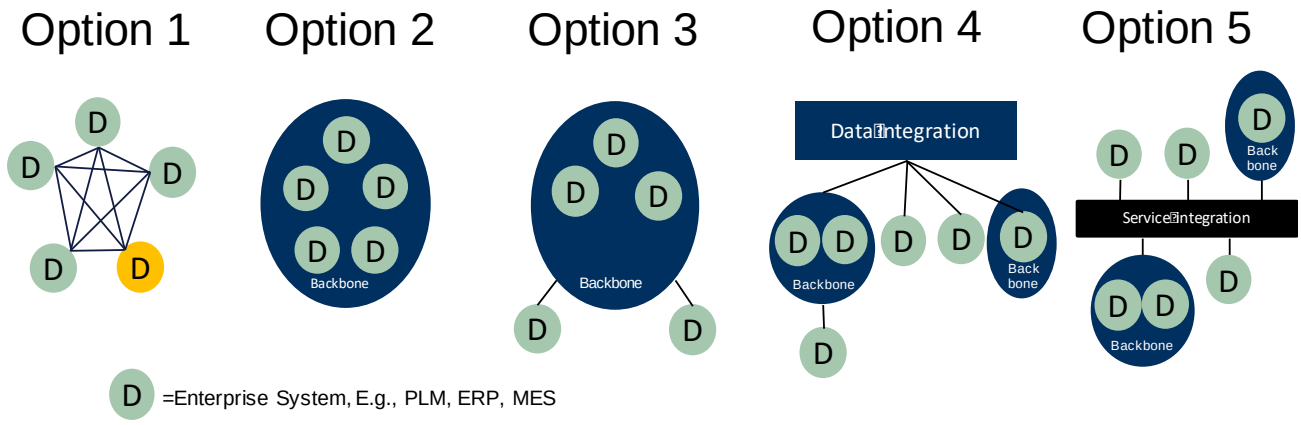

Figure 3–Architectural Patterns Considered within this Project

- ***Option 1, Direct Link—***This is approximately the current state of many member's PLM solutions. Point solutions, and some integrated solutions, both are connected using a mix of enterprise application integration technology and point-to-point integration solutions. The result is a complex environment that is difficult to enhance, leverage, or upgrade.
- ***Option 2, Unique Backbone—***All applications are centrally controlled within a unique backbone. This centralized approach generally requires a single source data repository. Integration of applications from different sources to obtain unique capabilities is problematic for both technical and inter-vendor business relationships, ultimately limiting innovation.
- ***Option 3, Central Backbone Supporting External Integrations—***This is typical strategy from today's solution providers. It adds complexity with semantics and linked data, as well as having similar limitations to Option 2.
- ***Option 4, Federation of Multiple Backbones—***Point solutions and integrated suites are connected via federation to an integrated data layer. While data is exposed in neutral formats, the environment is complex to configure and maintain due to proprietary and legacy technology. This is conceptually similar to Option 6, our chosen direction but with technology limitations.
- ***Option 5, Full Service Bus Integration (SOA)—***Data and processes from point solutions and integrated suites are connected using services. While this service based architecture has had some

success and demonstrated efficiencies it has several limitations due to legacy technology. Data sources aren't protected and direct requests to data have performance impacts. Inconsistency in APIs and data semantics limit usability without customization of interfaces.

- ***Option 6, System of Systems—***A service-based architecture with systems containing groups of services, based on standards, supports efficiency while maintaining proper governance. This is the Option selected by the project team.

Common Architecture Pattern

The selected architectural pattern, Option 6 is shown in Figure 4. Conceptually, it is a dynamically reconfigurable system of systems. It should be able to scale to enable an extended enterprise of business entities, configured to support global supply chain and joint venture requirements. It is a service oriented architecture (SOA) where legacy and future systems expose services that provide access to data via standard formats and protocols whenever possible.

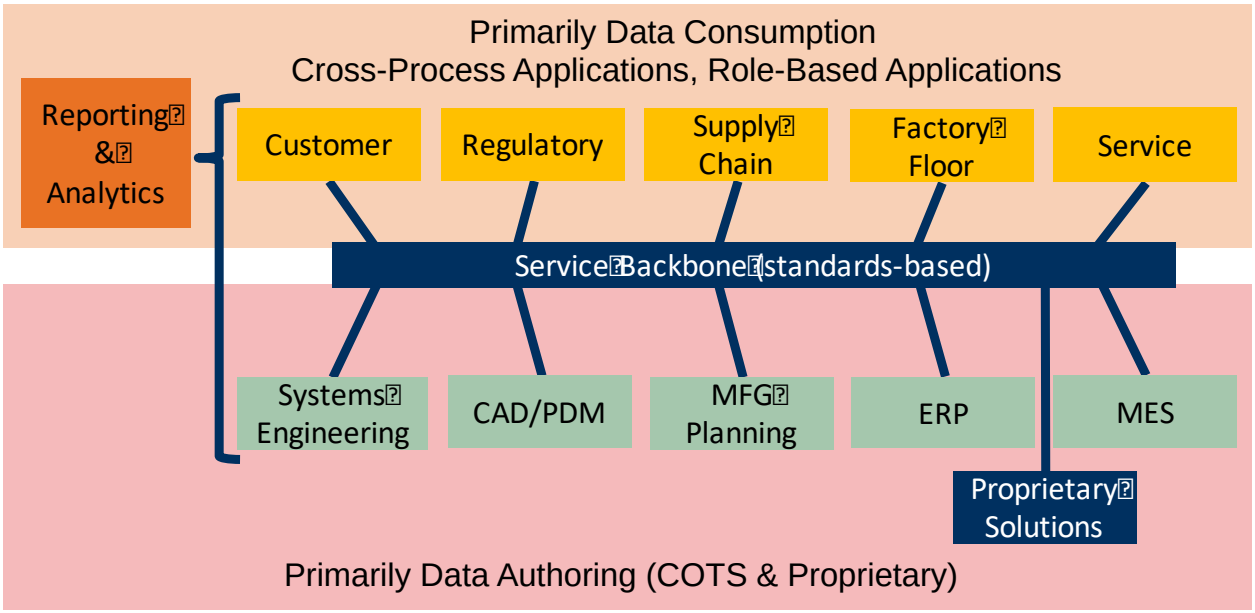

Figure 4—System of Systems Architecture to Maximize Resilience, Support Modularity, and Minimize the Cost and Risk of Obsolescence

With this architectural pattern, constituent systems do not need to be reengineered and asset reuse is maximized. In addition, this architecture provides flexibility in decisions regarding tradeoffs between many simple systems versus a few complex systems.

Figure **5** and Figure 6 show possible configurations that provide consumers with access to data and information as a business service regardless of individual system boundaries.

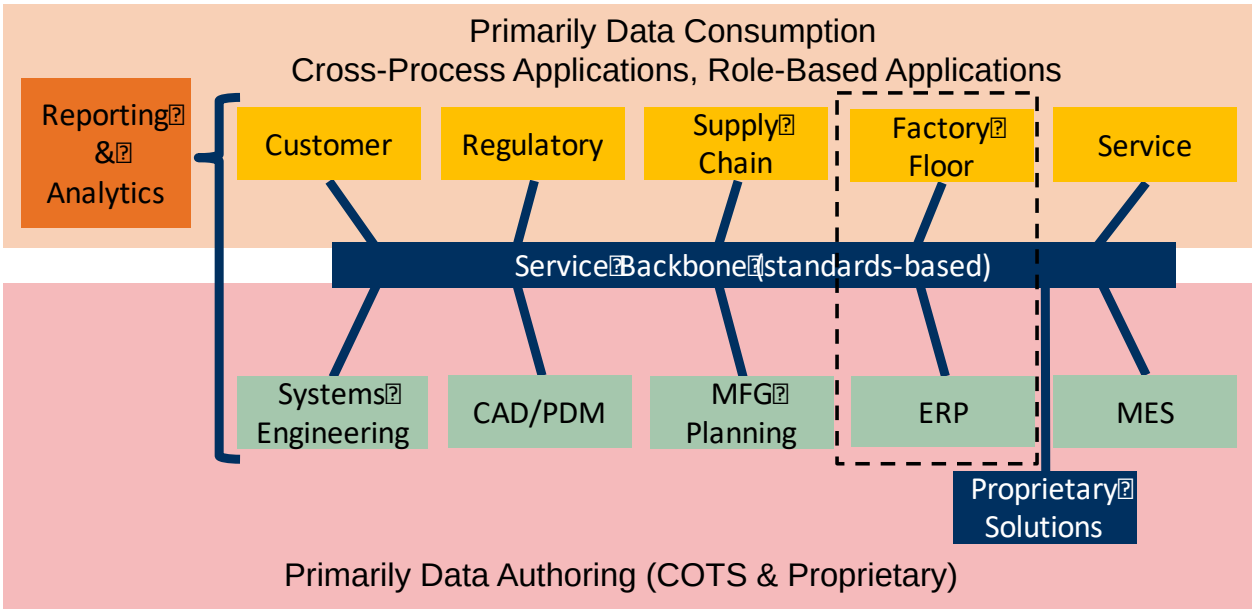

Figure 5—Dashed Line Shows a Configuration Where Factory Floor Accesses Data Stored in ERP to Support Manufacturing Operations

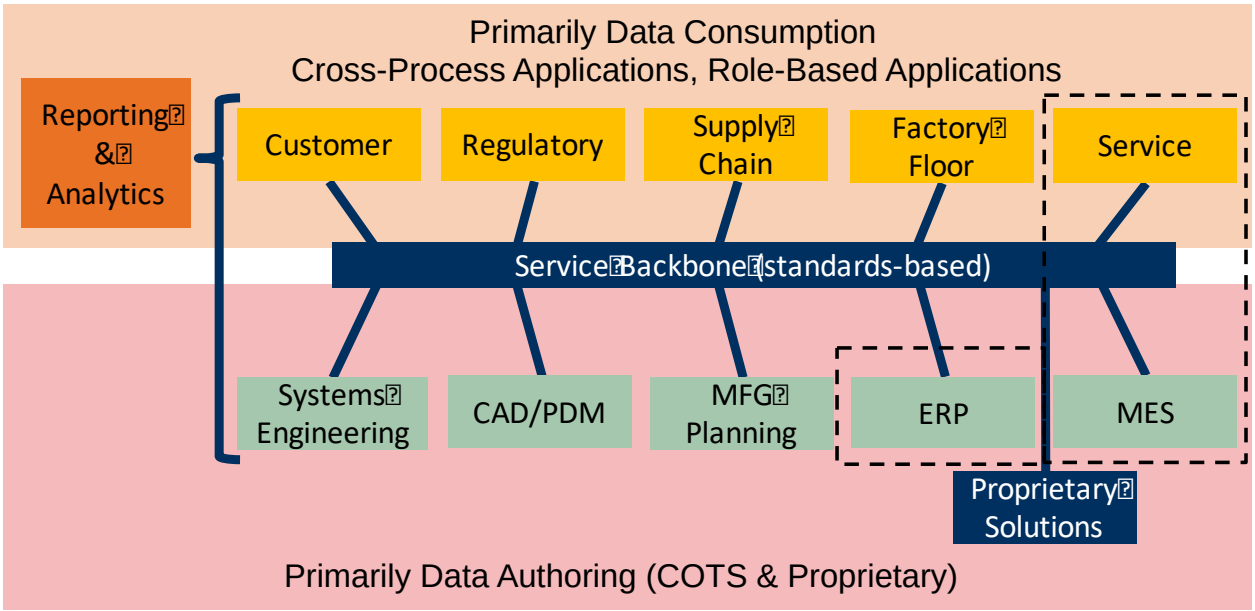

Figure 6—Dashed Line Shows a Configuration Where the Service Organization Accesses Data Stored in ERP and MES to Provide Support Services

Perhaps the most important feature of this architecture is the integration strategy, as it exposes data and enables communication between applications. Ideally, data is federated from the master source rather than being copied as dependent data. Each system within the system of systems exposes services at a relatively granular level, and those services are combined into more sophisticated business services via standards-based integration technology.

The intent is to leverage standards including OSLC and STEP whenever possible, and to extend those standards only where necessary. Standards bodies will be lobbied to ensure that any gaps are filled over time. Figure 7 shows the high-level requirements for integration.

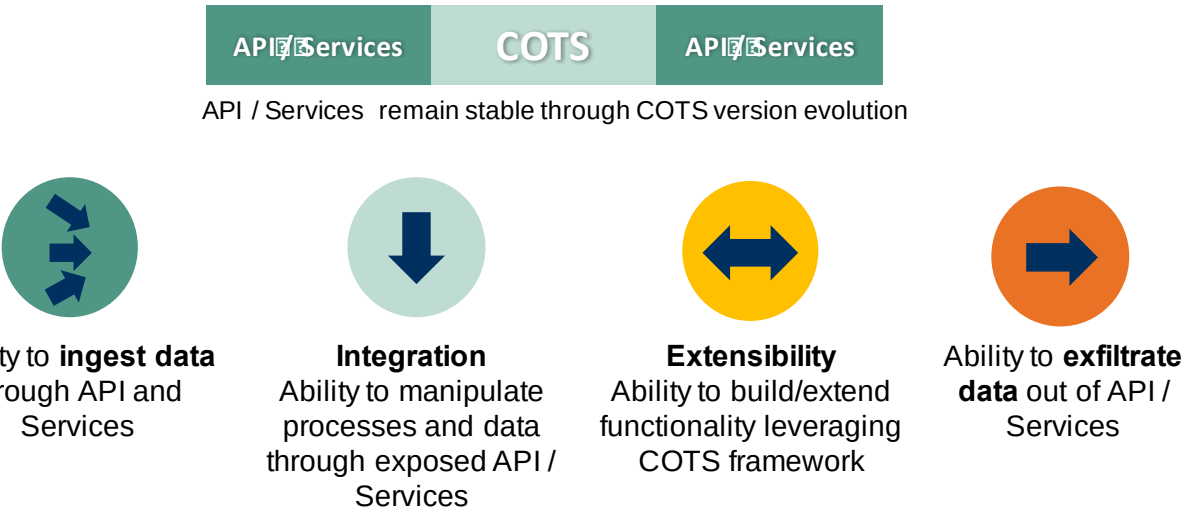

Figure 7—Robust, Comprehensive Integration Support is Required to Enable a System of Systems Architecture

Architecture Principles

Based on the conceptual architecture described above, the project team identified the following high level framework of principles for the future desired state architecture:

- ***Information Centric—***The product data and metadata, stored within the PLM solution that describes the product must be fully exposed, accessible, and managed, independent of the underlying IT technology. The PLM solution architecture must be optimized to make information accessible and usable.
- ***Sustainable—***The complete PLM solution (i.e., the software, processes enabled, and support services) must be able to meet the company's business needs now and well into the future via continuous and cost effective improvements, rather than a series of discontinuous, high-intensity, and costly upgrade events. It is expected that the entire suite of member endorsed product data standards will be the same level of fidelity as those that support the solution providers own proprietary formats. Customizations shall carry forward to new releases with minimal recoding and testing.
- ***Incrementally Deployable—***The elements of the PLM solutions must have a modular architecture that cooperates with legacy solutions to minimize migration efforts and disruption. The architecture must allow modules to be replaced, upgraded, or substituted, with minimal cost and risk.
- ***Globally Available—***The PLM solution must support extensible security models and communication protocols.
- ***Analytics Enabled—***The PLM solutions should expose data so it can be consumed by data analytics and reporting processes.
- ***Standards Compliant—***The PLM solution must fully support the entire suite of member endorsed product data standards at the same level of fidelity as they support their own proprietary

data formats. Proprietary solutions or draft standards can be used when standard based alternatives are not available, but should be replaced as soon as a standard is available and stable.

Business Benefits

The high-level business benefits that this proposed architecture will achieve include:

Data Retention Through Program Life

By basing data formats on existing standards and ensuring that data formats are completely described, data will be accessible and reusable, for example to design a derivative product or to perform service operations, even if the originating application is no longer available. Proprietary formats will no longer lock in an application making it easier to upgrade as well as migrate to a new technology or solution provider. Data will be reusable rather than locked into proprietary archives. Standard data formats and integration services will enable interoperability between solution provider technologies as well as within a single provider's solution set enabling companies to focus on improving their products without being limited by their product development solutions.

Solution providers will also gain significant benefits from standards-based data formats. Old applications and software code can be retired reducing maintenance and support costs. As most solution providers have significant code bases on multiple platforms, interoperability within suites as well as with competitors' products will be simplified allowing more resources to be devoted to innovation. With easier interoperability and data access, it will be easier to integrate new capabilities into existing environments shortening the sales cycle because changes and additions will not impact top level governance issues.

Different PLM Solutions Between Programs

Heterogeneous PLM solutions will exist within companies for the foreseeable future. Different business needs between divisions, programs, and acquisitions as well as the competition in the marketplace are all drivers of heterogeneity. Format and interface standardization will allow data reuse across the various organizational divisions much easier, reducing cost and schedule while improving quality by ensuring access to validated, proven components and systems.

Solution providers will benefit because there will be less need for a homogenous environment so they can compete on characteristics like innovation and customer service rather than the single vendor, winner take all, standardization. Solution providers will compete at the capability level, and will be able to sell technology where they are better, and will also be able to incrementally swap out competitor's products without having to wait for the next PLM platform generational change.

PLM Platform Generational Changes

The proposed architecture has two key characteristics that improve business performance. The open data formats and services for integration will improve interoperability allowing incremental updates and even groups working at different release levels to collaborate. By supporting incremental upgrades, new technology can be deployed incrementally which reduces risk when something goes wrong and requires fewer people because less of the solution is changing at any given time (although the time span to roll out the equivalent amount of technology may be longer).

Solution providers will be able to incrementally swap out competitors' products, or their own, without having to wait for the next PLM platform generational change. In addition, solutions will be easier to upgrade and or augment, so the older programs can be brought up to date and enhanced, simplifying the source environment, lowering both technology and support costs.

Requirements

The following requirements define the changes that must be met to achieve the objectives outlined above.

List of Requirements

Roadmap Visibility

- The solution provider shall regularly (annually) provide OEM with roadmap and strategy for future PLM product versions.
- The solution provider shall provide a 2-year visibility into the future on all new/obsolete/discontinued features regularly (annually).
- The solution provider shall provide a complete analysis of their OEM capabilities for each new release relative to previous releases.
- The solution provider shall provide a forecast of compatibility issues against a 2-year roadmap of future capabilities.

Software Compatibility Matrix

- The solution provider shall provide a support continuity for third-party components at next maintenance release (i.e. upward compatibility for all functions).
- The solution provider shall support current version and three previous versions of a mutually agreed list of third-party tools.
- PLM software products shall allow reuse of legacy data as underlying read-only data sets, and allow integration of additional data sets for definition of new product solutions.
- PLM software products shall provide notification of changes to the original data in the newer solution sets.

Software and Data Upgradability

- The solution provider shall deliver any software feature's replacement in the frame of feature continuity of version-to-version upgrades.
- The solution provider shall provide:
  - Configuration continuity—full reusability in three subsequent versions
  - Database and data model continuity—full reusability in three subsequent versions
  - Data quality assurance mechanisms—upward compatibility in three subsequent versions
  - GUI technology continuity—including technology and framework change; the provider complies with a mutually agreed continuity plan
  - API continuity—the existing API and services will not be removed or disabled for three subsequent versions

- Metadata interchangeability with other applications—appropriate import and export capabilities in line with standards
- Data after the product release—fully covered by industry standards including LOTAR, and not affected by tool generation changes
- Work in progress data representing work products before the release—maintain any capability that allows creation of such work in progress data inside their solution for three subsequent versions
- persistence of data version to version inside the PLM software providers' products without major cost or effort on the side of the users.

Upgrade Process and Tools

- The solution provider shall deliver an upgrade tool as well as maintenance services for each version or release
- The solution provider shall upgrade to a newer maintenance release and version
- The solution provider shall make sure that customizations can be brought forward on four (TBC) future releases with minimal (TBD) effort (code changes and testing)
- The solution provider shall provide the tools, documentation, and procedures for automatic upgrades of:
  - Software
  - Configuration
  - Database

Requested Response

PLM technology obsolescence management is a big concern within the A&D industry, and will likely never go away. To address obsolescence related issues, the A&D industry needs its solution providers to support the principles and requirements defined in this document. Many of the concepts including system of systems, SOA, and platforms have already been embraced and are being implemented within the latest versions of commercial product architectures from many of the PLM solution providers. However, ensuring that these architecture transformations are complete and able to support the A&D industries legacy data and processes is a complex challenge. We need to work together to successfully meet this challenge.

The A&D PLM Action Group wrote this paper to demonstrate our understanding of the issues and communicate our intent.

The project team recommends that member companies address the above requirements in future contracts between member companies and PLM solution vendors.

About A&D PLM Action Group

The Aerospace & Defense PLM Action Group is an association of aerospace OEMs and aircraft engine providers within CIMdata's globally recognized PLM Community Program, which functions as a ***PLM advocacy group*** to:

- Set the direction for the aerospace & defense industry on PLM-related topics that matter to members (*including promoting, not duplicating, the work of standards bodies*)
- Promote common industry PLM processes and practices
- Define requirements for common interest PLM-related capabilities
- Communicate with a unified voice to PLM solution providers
- Sponsor collaborative PLM research on prioritized industry and technology topics

CIMdata administers Action Group operations, coordinates research, and manages the progression of policy formulation.

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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