

Interoperability Standards for Aerospace & Defense

Problem Statement, Objectives, Desired State,
Recommendations, and Go Forward Plan

Release 1.0

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AEROSPACE & DEFENSE PLM ACTION GROUP

Abstract

Collaboration within a large, global, distributed supply chain of design and development partners is seriously hindered by both ineffective implementation of interoperability standards industry-wide and selective capabilities embraced by PLM providers. These two factors prevent the digital continuity needed to set up a Model-Based Enterprise. Future A&D development of civil aircraft, aerospace products, and associated systems will rely on model-based paradigms. A Model-Based Enterprise will require long-term archiving and retrieval of the associated model-based design, more specialized and complex data structures, and management of their meta data. Globally, PLM interoperability standards are identified as key enablers to support the new ways of working, based on the introduction of digital twins that will exist in a digital ecosystem.

This position paper supports the A&D industry by identifying international standards of high business value, recommending their incorporation into PLM systems and integrations, and using them in operation within A&D companies and also with their supply chains. This paper is iterative and will be extended with future editions that support new PLM interoperability capabilities requested by the AD PAG.

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Revision Record

Release	Date	Description
1.0	January 2022	Initial release of Edition 1, to be expanded progressively as standards recommendations grow to meet AD PAG needs

Interoperability Standards for Aerospace & Defense

Executive Summary

The Aerospace and Defense Product Lifecycle Management Action Group (AD PAG) is an association of aerospace Original Equipment Manufacturers (OEMs) and aircraft engine providers within CIMdata’s globally recognized PLM Community Program, which functions as a PLM advocacy group. One of the primary business issues identified by the AD PAG is that collaboration within a large, global, distributed supply chain of design and development partners is seriously hindered by a lack of interoperability standards implementation within the industry and by the PLM providers. Consequently, this has prevented the digital continuity required to set up a Model-Based Enterprise. Future development of civil aircraft, aerospace platforms, and associated systems will rely intensively on model-based paradigms, which require long-term archiving and retrieval of the associated model-based designs, more specialized and complex data structures, and careful management of their meta data. There remain many gaps relative to the implementation of interoperability standards by the PLM providers, industrial integrators, and the industry as a whole. More globally, PLM interoperability standards are recognized as key enablers of the new ways of working, based on the introduction of the digital twin.

Previous work by the AD PAG identified an initial list of recommended standards¹. To expand on this effort, a project team of domain experts from the AD PAG member companies was established to prepare the first edition of this position paper. This Standards team coordinated with the four primary AD PAG project teams (sometimes referred to as *working groups or workgroups*): Model-Based Design, Model-Based Systems Engineering, Multi-View Bill of Materials, and Global Collaboration.

This position paper addresses the primary business requirements for PLM interoperability. PLM interoperability standards describe the principles, requirements, sub-processes, dictionaries, information models, data formats, and services that are interdependent. In total, these standards and the recommendations resulting from their adoption form the basis for a computer-interpretable, end-to-end representation of the product through its defining data.

The overall business value of digitally mastered standards that enable Model-Based Enterprise interoperability is summarized in this document. Built from the ground up, model-based standards will unlock additional value through increased speed-of-development and widespread adoption in industrial scenarios. The criteria for selecting the recommended standards and their associated interoperability forums are described, while also noting the role of the interoperability forums to accelerate the deployment of Commercial Off-the-Shelf (COTS) standardized interfaces.

Finally, this position paper identifies a first list of fifteen fundamental international standards of strong interest to the AD PAG. The document concludes with the definition of an action plan (i.e., Go Forward Plan) that addresses preparing key indicators for the follow up of

¹ <https://www.cimdata.com/en/aerospace-and-defense/publications/standards>

- Implementing the recommended standards by the PLM solution providers
- Testing by the appropriate interoperability forums
- Deploying the standards by the A&D industry and its supply chains

Follow-on editions of this position paper will extend the list of standards to support new PLM interoperability capabilities requested by the A&D PAG.

Introduction

In March 2016, executives from the AD PAG member companies—Airbus, Boeing, Embraer, Gulfstream, and Rolls-Royce—met with the intent that informal discussions of Product Lifecycle Management (PLM)-related issues would lead to agreement on common objectives, requirements, and plans for remediation of their common PLM pain points.

This 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 roadmaps for eliminating or significantly reducing a key inhibitor to the value potential of PLM. The topic addressed by this particular project, which was initiated in 2019, is the definition of a list of key standards to support the PLM interoperability requirements of the aerospace and defense (A&D) industry.

Since the initial agreement in 2016, AD PAG membership has increased from five to nine OEMs and suppliers, including the addition of GE Aviation, Pratt & Whitney Canada, and Safran, and this Standards project team has added domain experts, also known as *subject matter experts* (SMEs), from many of them.²

The scope of this Standards team’s activity has been to agree on a set of recommended standards to support the primary priorities of the different working groups (i.e., teams) and to identify related interoperability forums that are the enablers—those who will accelerate the implementation speed of the related PLM interoperability solutions.

Problem Statement—From CAD Data Exchange to Model-Based Enterprise Interoperability

Substantial effort has been made in the past 20 years to develop ISO standards and implement solutions for the exchange of Computer-Aided Design (CAD) assembly structure with 3D geometry and Geometric Dimensions and Tolerancing (GD&T). Now, a challenge is to accelerate the operational use of the solutions, enabling the digital thread across the full product lifecycle, between different manufacturers, and among different PLM applications.

The exchange of Product Data Management (PDM) to PDM CAD and BOM data among airframers, engine manufacturers, and other partner companies within the A&D industry can best be described as tedious. Each company has different PLM software systems, versions, and customizations, and different CAD software systems and versions. Exchanging data between any two companies requires bi-directional agreements of exchange—how to handle errors and

² Bombardier and Dassault Aviation, both AD PAG members contributed to initial content of this paper and are currently not members of the AD PAG.

expansion of the exchange process, as well as how to protect Intellectual Property (IP) data. Unfortunately, no single standard for either CAD or PLM data exchange exists.

Establishing a digital thread and Model-Based Enterprise includes Model-Based Systems Engineering (MBSE), Model-Based Definitions per digital integrated processes, Model-Based Manufacturing, and Model-Based Support, and it requires that every model be managed via configuration management best practices across all product lifecycle stages.

This increase in scope and complexity results in the need for numerous PLM interoperability standards to address the high cost of development and implementation and to define the appropriate quality level. Lack of coordination between A&D manufacturers would lead to a risk of misalignment in the request of PLM interoperability standards, resulting in high usage costs and longer implementation time by PLM providers. The challenges are addressed in this position paper by identifying and presenting a first set of high priority PLM interoperability standards for the ongoing activities of the AD PAG.

Objectives for PLM Interoperability

The vision for PLM interoperability is that the recommended standards support the following key business objectives of the A&D industry:

- Identify the general business requirements of PLM interoperability
- Describe the value of digital standards to support Model-Based Enterprise interoperability
- Exchange and share PLM information through the full product lifecycle, based on open international standards
- Protect the digital assets of A&D OEMs and equipment manufacturers to ease global collaboration
- Deploy the following Model-Based Enterprise principles:
 - Digital thread across the full product lifecycle, including services
 - Support of the digital twins

Approach

As a starting point, a short list of key standards for the AD PAG was identified, with the understanding that the list would be extended progressively. The approach for this first edition was based on close coordination with the following four AD PAG project teams (sometimes referred to as *working groups* in this position paper), each focused on a specific technical domain:

- Model-Based Definition (MBD) and Bill of Materials (BOM) Definition
- Multi-View BOM
- Global Collaboration
- Model-Based Systems Engineering (MBSE)
- Digital Twins /Digital Thread³

The following activities were conducted for each project team:

³ New team created; requirements still to be determined.

- Documented the pain points and business requirements for interoperability standards
- Noted potential, state-of-the-art PLM interoperability standards that address the problems to be solved
- Identified a minimal list of key standards that add strong business value to the project teams’ objectives

This current edition is the result of coordination with the four teams and is structured to address the following:

- Identification of the general business requirements for PLM interoperability
Description of the business value of digital standards to support Model-Based Enterprise interoperability
- Summarization of the role and values of interoperability forums
- Identification of criteria for selecting the recommended standards and associated interoperability forum
- Listing of the key, recommended, PLM interoperability standards for Edition 1
- Identification of the next actions to take

Business Requirements for PLM Interoperability

Each company has its own exchange requirements. Consequently, exchanging data requires independent and exclusive processes—each unique and complicated—to support the long-term future of collaboration. The development and availability of exchange standards that all solution providers and companies adhere to would greatly facilitate and optimize evolution of the future collaboration process.

Manufacturing Standards Becoming SMART Standards

Technical standards cover nearly all manufacturers’ activities: engineering, manufacturing, in-services, and quality control. They are increasingly implemented in COTS applications, creating information to be controlled (quality), shared, migrated, queried, visualized, and archived. With the digitalization of the A&D industry, the resulting technical standards are becoming SMART⁴ standards. They can be viewed by humans, read by machines, and processed by applications.

⁴ ISO SMART standard: “Standards Machine Applicable, Readable and Transferable” is a project in the launch phase within ISO that seeks to revamp the development, delivery, and utilization of the ISO standard.

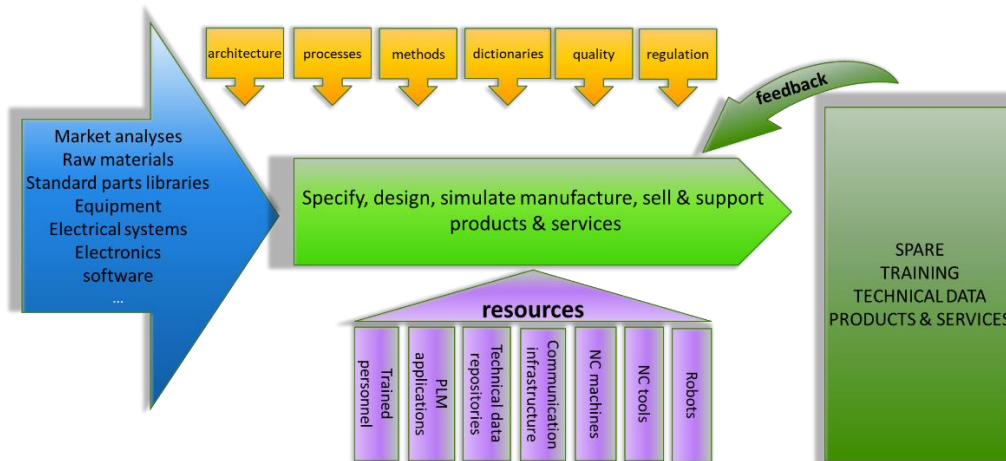


Figure 1 - Technical Standards Becoming Machine-Readable SMART Standards, Covering All Manufacturers' Activities

Generic Business Requirements for PLM Interoperability

Core to the concept of PLM is universal access to product data. CIMdata defines PLM⁵ as a strategic business approach that applies a consistent set of business solutions that support the collaborative creation, management, dissemination, and use of product definition information by:

- Supporting the extended enterprise (customers, design, and supply partners, etc.)
- Spanning from concept to end of life of a product or plant
- Integrating people, processes, business systems, and information

The benefits of Model-Based Definition, Model-Based Manufacturing, and Model-Based Support, in close relationship with Model-Based Systems Engineering, can be reached only if seamless digital continuity is ensured throughout the full product lifecycle, including support services and dismantlement.

The following generic use case requirements for PLM interoperability must be taken into account by all A&D manufacturers, their supply chains, and their customers:

- Integration between the information technology (IT) applications within the company
- Communication
 - Collaboration with the extended enterprise during product definition and manufacturing
 - Collaboration with the customers / airlines and Maintenance, Repair, and Operations (MROs),
- Migration of applications—legacy or COTS applications—with a change of generations often shorter than the duration of the A&D product lifecycle, which can extend from 50 to 70 years
- Long Term Archiving and Retrieval (LOTAR) of PLM information for fulfillment of certification requirements and also for digital assets management, operations support, and product derivatives preparation
- Analytics / Artificial intelligence

⁵ CIMdata Product Lifecycle Management Definition: <https://www.cimdata.com/en/resources/about-plm>

- Digital twins

The three dimensions of PLM data interoperability across the supply network, across business functions, and through the lifecycle—are illustrated below.

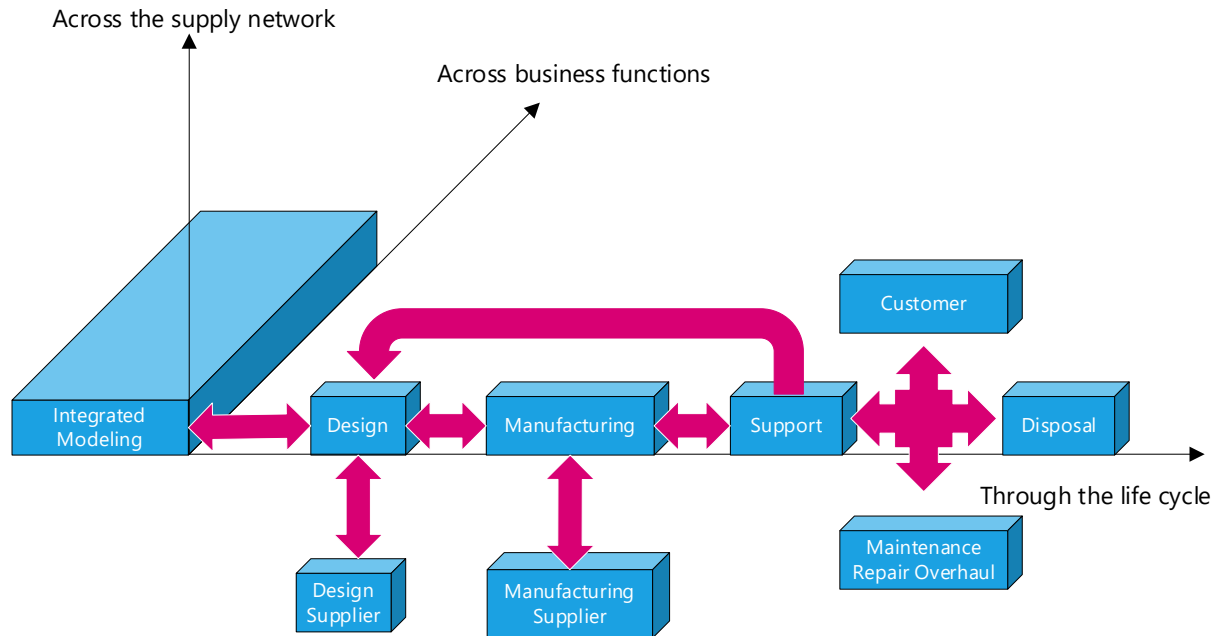


Figure 2⁶ - Three Information Dimensions of PLM Data Interoperability

This PLM information supports the digital thread across the full product lifecycle by doing the following:

- Providing a linked view of the data throughout the lifecycle, which enables the digital thread to cross Engineering (Design), Manufacturing, and Support
- Exposing the data across the supply network, which enables communication between the OEM, Tier 1 Supplier, Tier 2 Supplier, etc. in a supply chain ecosystem
- Facilitating the communication of PLM data across the business functions, which enables organizational interfaces to operate efficiently between Mechanical, Electrical, Software, and other areas that contribute to the final product design

⁶ ISO/TC 184/SC 4 N1167 “SC4 industrial data framework”

Framework for Intra- and Inter-Enterprise Interoperability

Communication between intra- and inter-enterprises requires agreement among several areas. ISO 11354 “Requirements for establishing manufacturing enterprise process interoperability” highlights the four crucial domains: business, processes, services, and data that are represented in the following figure.

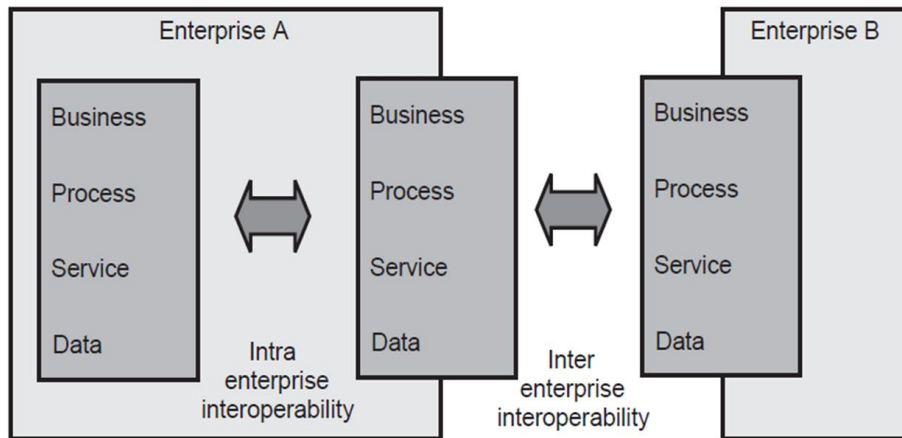


Figure 3 - Interoperability concerns for establishing manufacturing enterprise process interoperability

Enterprise systems fail to interoperate because of various categories of barriers. These barriers can be overcome, and interoperability can be realized by several means, such as specific point-to-point solutions or by interoperability capabilities based on open standards. ISO 11354⁷ provides a framework to classify the interoperability barriers, along with the concerns and approaches, and the various layers among them.

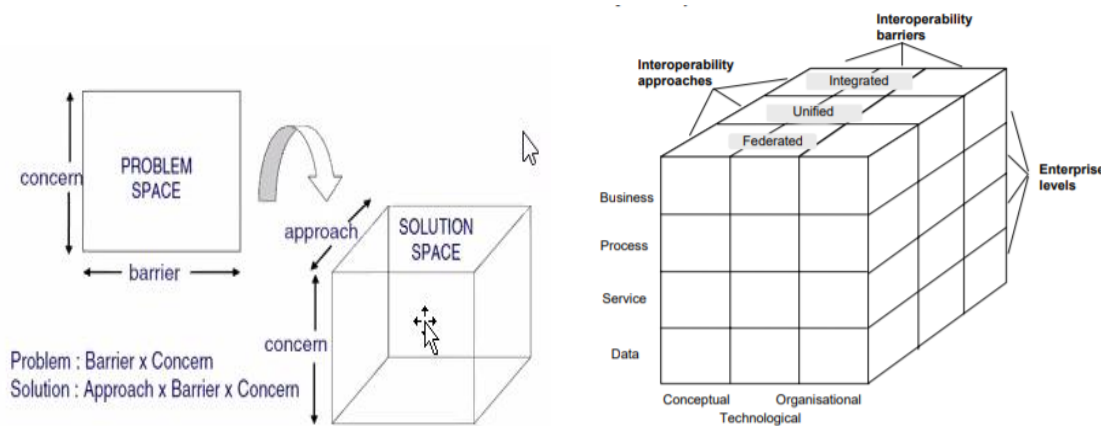


Figure 4 - Three Dimensions of the Framework for Enterprise Interoperability

It’s important to note that barriers exist at data, service, process, and business enterprise levels (concerns) and are conceptual, technological, and organizational in nature. Therefore, when

⁷ ISO 11354 “Requirements for establishing manufacturing enterprise process interoperability - Part 1: Framework for enterprise interoperability”

evaluating standards, it is imperative to be precise about what interoperability aspect a standard is resolving.

The third axis of approach suggests that the possible logical implementation approaches (i.e., federated, unified, integrated) may have a bearing on a standard’s implementation challenges and the standard’s ability to interoperate with other standards. Refer to *Appendix A: Classification of Standards to Support Model-Based Enterprise Interoperability* for details about the types of interoperability problems to be solved, as well as additional information about layers.

Business Value of Digital Standards to Support Model-Based Enterprise Interoperability

Recalling the problem statement regarding the difficulties in exchanging data, state-of-the-art demands have led to intensive use of complex digital models, specialized by activities and technical disciplines, and including close coupling between definition and simulation, to optimize the overall product (i.e., definition, manufacturing, quality, cost, maintenance, etc.). These activities create and use highly complex, technical data with associated meta data that is the foundation of the digital thread in the Model-Based Enterprise. New ways of working have revealed opportunities and benefits in the use of interoperability standards, machine readable versions of standards, the implementation of digital twin, and semantic modeling.

Key Business Benefits of PLM Standards

International open standards that support PLM interoperability are key to the A&D industry. PLM interoperability based on open standards enables digital continuity throughout the lifecycle, across the supply chain extended enterprise, and across business functions.

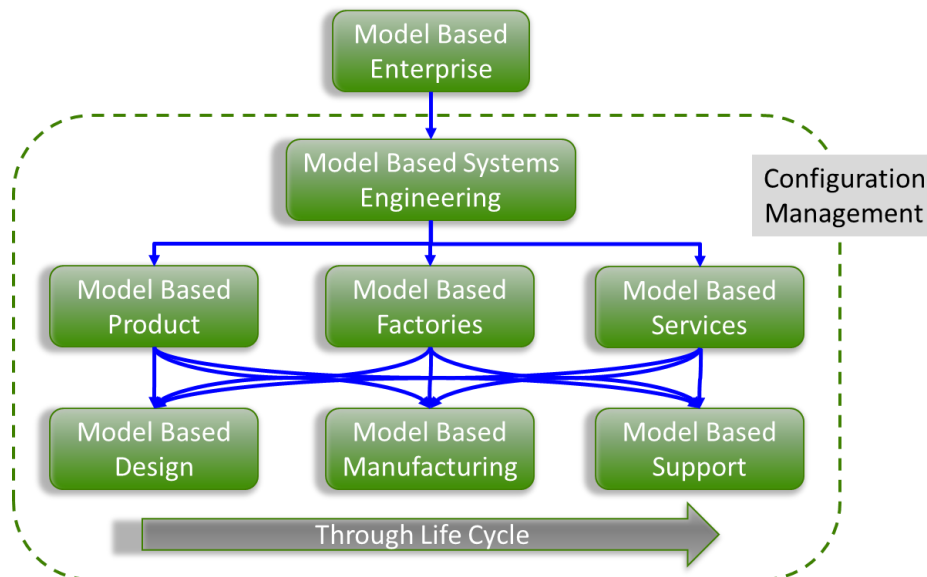


Figure 2 - PLM Interoperability Standards Support of the Model-Based Enterprise

The standards are critical with regard to the following:

- End-to-end extended enterprise PLM model-based processes: Model-Based Design, Model-Based Manufacturing, and Model-Based Support, all supporting the Model-Based Enterprise while applying Model-Based Systems Engineering principles
- Retention of digital enterprise data assets and knowledge
 - Standardized data in open formats is a strong enabler to support analytics
 - Artificial Intelligence requires high quality stable data,
- Digital twins and Industrial Internet of Things (IIOT)
- Interoperability of federated systems of OEMs and their suppliers, across the full lifecycle, based on a set of federated machine-readable standards

PLM interoperability standards allow manufacturers to achieve the following benefits:

- Minimize customization and maximize COTS capabilities
- Increase obsolescence resilience
- Provide long-term sustainability of the company’s digital assets
- Enable convergence on consensus information models
- Enable better control and optimization of Total Cost of Ownership (TCO)
- Enable introduction of future technologies

Key Role of Machine-Readable Standards to Set Up Digital Twins

During development of the product until its operational use and disposal, different types of digital models are created, built on, or derived from each other, according to the product lifecycle. These models are associated with physical artifacts (i.e., a product, tooling, assembly line, operational environment, etc.), allowing advanced coupling mechanisms—enabling digital twins.

Ultimately, dedicated digital twins will be used for operations support, with the level of security requested by the airworthiness authorities and with a longevity that may extend over 50 years. Machine-readable data based on standards will play a key role to ensure the appropriate level of openness, associativity, and accessibility throughout the lifetime of these models and related meta data.

The following figure illustrates the concept of a digital twin within the context of the product lifecycle. Much like a large communications cable that contains many individual strands, each with its own packets of data, the digital twin is built with model-based contributions from each discipline that contributed to the model-based design. Taken in total, the digital twin represents the virtualized instance of the product embodied by a set of standards that define the data and the reference to the source authority.

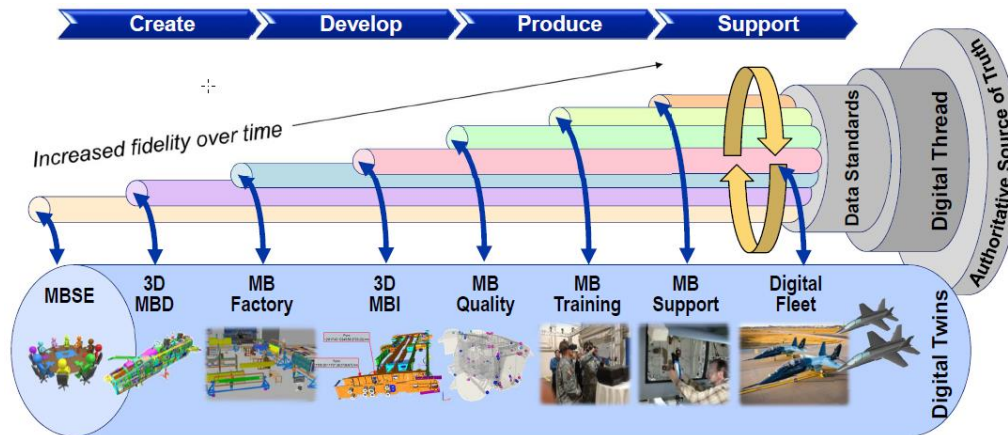


Figure 3 - Strategic Value of Standards in Digital Transformation—ISO/TC 184/SC 4 Industry Day – May 15, 2019 The Boeing Company

Progression of Digital Twins Readiness Based on Semantic Modeling

For the digital twins concept to be realized, the standards upon which digital twins are defined must be capable of digital integration. Today, most standards are still built for human consumption, delivered via document-based paradigms, and manually curated into company IT systems. The introduction of IT solutions has reduced pain in several areas, yet the standard continues to be a document. As indicated earlier, like the product, a data standard's future is to be SMART—one that is computer-interpretable directly where the data specification is immediately defined by the model that exists within the standard.

The following figure describes the stair-step progression, or maturity-based approach, that must occur for standards to be SMART and support the digital twin. Today, standards are quite adept at terms, and many classify terminology within the standard. To reach digital twins readiness, standards will be required to align industry-driven taxonomies and ontologies. This will enable the interpretation across standards that connect the digital twins from domain to domain. Ultimately, a Top-Level Ontology (TLO) will connect the digital twins to their ecosystem context.

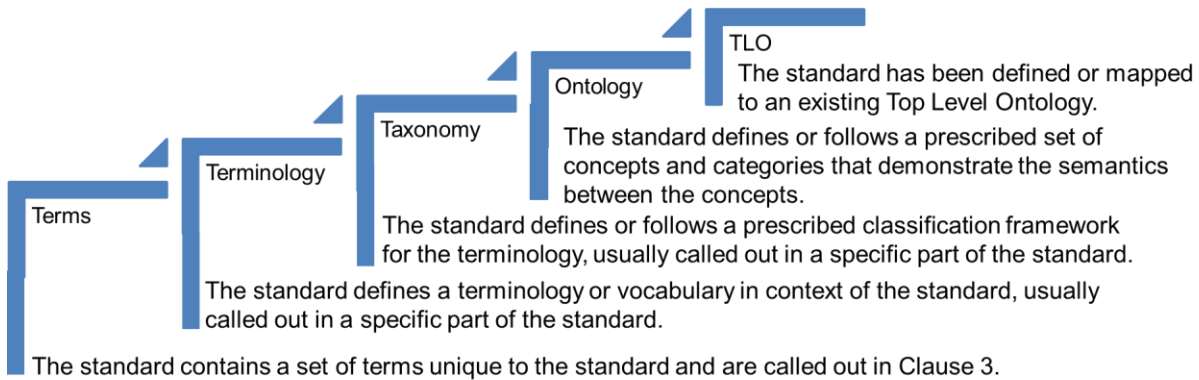


Figure 4 - Maturity-Based Approach to a SMART Standard

Understanding the progression from terms to ontologies relies on a reference model for appreciating the interactions of the artifacts important to any digital asset.

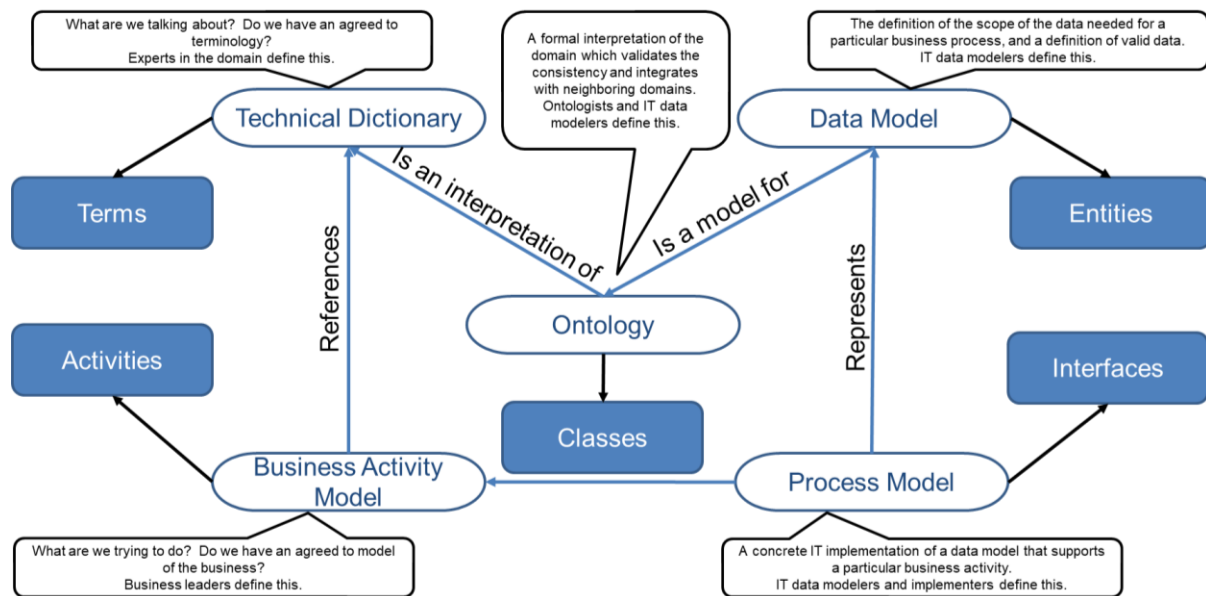


Figure 5 - Conceptual Model for Any Digital Asset

In the figure above, the different aspects of an information system are described, including the key question each product addresses, coupled with the relationship of that product to other products in the information reference model. Many of today’s standards have focused on the Business Activity Model, the Process Model, and the Data Model. To advance the maturity of these models and support digital twins aspirations, sharing across domains comes with an investment in technical dictionaries and ontologies.

Role and Value of Interoperability Forums

The objective of the AD PAG is to recommend PLM interoperability standards that are implemented and deployed as COTS solutions by the main PLM providers and/or integrators. This allows minimizing the cost of ownership of standards-based PLM interoperability solutions.

Interoperability forums have proven that they add great value to accelerating the deployment of interoperable COTS solutions developed by different PLM providers and integrators, driven by priorities agreed to by the manufacturers. The absence of such an organization may result in the lack of synergy between the manufacturers in their request of PLM providers to develop standards-based interfaces. Usually, this lack of engagement would increase the total cost of development, extend planning, and decrease the quality of PLM information interoperability.

Therefore, once the standard is developed and released, a strong value exists for the A&D industry to define common use cases and align their priorities of implementing the related standard interfaces or services offered by PLM providers. That is the role of the User Group of the Interoperability Forum.

Then, independent technical coordinators, partially funded by the A&D industry, will organize interoperability test rounds between the different PLM providers and integrators, as members of the Implementation Group of the Interoperability Forum.

Additional descriptions of the principles and way an interoperability forum works are available, as a representative example, on the MBx Interoperability Forum web site⁸, which is supported by the AFNeT, PDES, Inc. and prostep ivip standardization associations. Some of the standards recommended in this position paper are associated with specific interoperability forums, such as the CAx IF⁹, EWIS IF¹⁰, PDM IF¹¹, 3D PDF IF¹², and JT IF¹³.

Selection Criteria for Interoperability Standards

Based on both the business requirements for PLM interoperability and the value of open PLM interoperability standards cited earlier in this position paper, the criteria used to select the set of PLM interoperability standards of highest value for the AD PAG are listed below:

- High value of the standard. This is regarding the principles, methods, and PLM interoperability capabilities for the related project of the AD PAG.
- Alignment with the vision. As summarized in this position paper, it covers the full product lifecycle.
- Consistency. Selected standards must be complementary and also minimize overlap of scope to maximize the benefits of implementation and deployment.
- Federation of standards. The need to cover the entire product lifecycle prevents the use of specific non-interoperable standards. The proposed goal is to rely on the ISO 10303 standard—made of a set

⁸ MBx IF: <https://www.cax-if.org/index.php>

⁹ CAx IF: https://www.cax-if.org/cax/cax_introduction.php

¹⁰ EWIS IF: https://www.cax-if.org/ewis/ewis_introduction.php

¹¹ PDM ID: <http://www.pdm-if.org/>

¹² 3D PDF IF: <http://3dpdfconsortium.org/implementor-forum/>

¹³ JT IF: <https://www.prostep.org/en/projects/jt-implementor-forum/>

of an Application Protocol focused on the exchange of product model data known as *STEP*—and to complete the lifecycle by using appropriate standards that cover specific needs.

- Consistency with A&D trade associations’ recommendations. The goal is to maximize the standards’ influence and adoption by the A&D industry, including with their supply chains and by the PLM solution providers. The selected standards will be aligned with the recommendations of the following:
 - American Aerospace and Defense trade association, represented by the AIA Business Technology Interoperability Committee (AIA BTIC)
 - European Aerospace and Defense trade associations, represented by the ASD Strategic Standardization Group (ASD SSG)
- Testing by interoperability forums, when relevant. In this case, the objective is to recommend standards tested in organizations with well-defined and efficient practices to accelerate the deployment of COTS PLM interfaces and services. As an example, refer to the various interoperability forums within the MBx Interoperability Forum at MBx IF: <https://www.cax-if.org/index.php>.
- Sharing with other industries, when relevant. The objective is to increase the synergies and strengthen the requirements of implementation by the PLM solution providers and integrators.

Desired State—Importance of Industry Alignment

An AD PAG-recommended¹⁴ list of standards is intended to help achieve the defined business benefits and contribute to the aligned efforts of the A&D industry at the following levels:

- Guidance of the PLM solution providers and integrators regarding the list of PLM interoperability standards to be delivered as Out-of-the-Box (OOTB) solutions
- Participation of the A&D industry with the standardization bodies in charge of these standards (maintenance and extensions)
- Participation of the A&D industry and PLM solution providers and integrators with the related interoperability forums to accelerate deployment of interoperable solutions of different providers
- Deployment of the interoperability solutions by the industry, based on COTS interfaces, with identification of lessons learned and potential requests of enhancements
- Link with the A&D trade associations, such as the AIA¹⁵ and the ASD¹⁶, via their dedicated committees in charge of coordinating PLM interoperability activities, respectively the Business Technology Interoperability Council (BTIC)¹⁷ and the Strategic Standardization Group (SSG)¹⁸; and disseminate common standards in large, medium, and small enterprises of the A&D industry

The following figure illustrates the links regarding PLM interoperability standards between the internal organizations of the AD PAG and the main, related, external organizations: standardization associations, standardization bodies, PLM solutions providers, and interoperability forums.

¹⁴ The recommendations in this document reflect a first version and will be updated over time by subsequent versions.

¹⁵ AIA - Aerospace Industries Association: <https://www.aia-aerospace.org/>

¹⁶ ASD - AeroSpace and Defiance Industries Association of Europe: <https://asd-europe.org/>

¹⁷ AIA BTIC: <https://www.aia-aerospace.org/committee/business-technology-interoperability-committee/>

¹⁸ ASD SSG: <http://www.asd-ssg.org/>

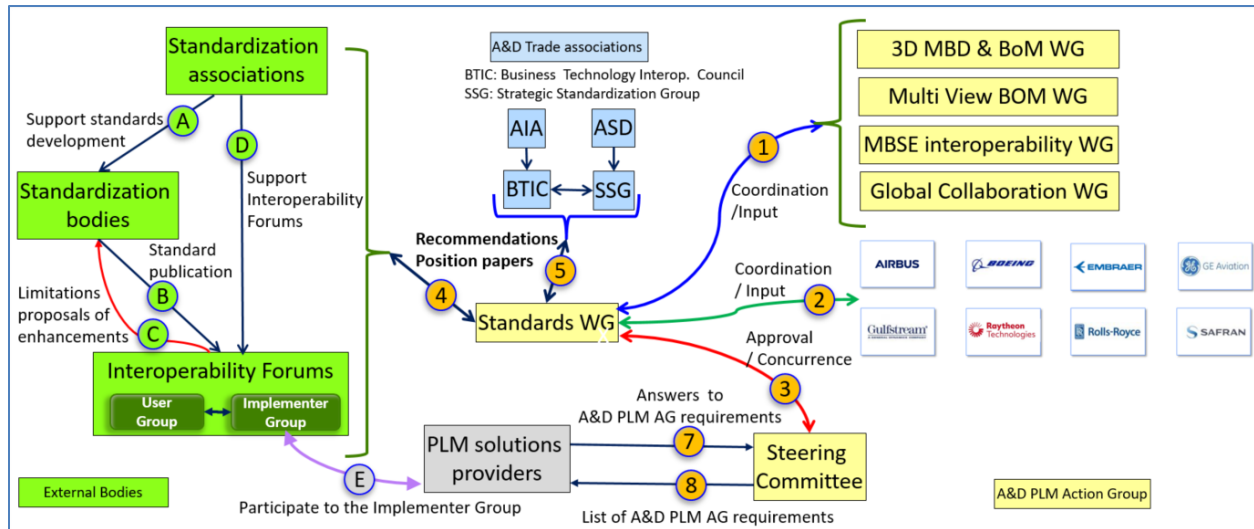


Figure 6 - Context of Elaboration of the Position Paper and Associated Activities Diagram

Key Standards Recommended by Each Team

Standards from each AD PAG project team (working group) are listed and described in the following sections. Each team’s business values, list of standards that align with those business values, and rationale for the selection are addressed.

Model-Based Definition (MBD) and BOM

This team's primary role is to evaluate current data interoperability standards, enabling a Model-Based Definition set of concepts, processes, and tools that allow the creation of a semantically (computer interpretable) annotated 3D product definition that is linked to a BOM system.

Business Values

Open data exchange, long-term archiving, and visualization standards are requested to support the full benefits of the digital thread of aerospace processes between Model-Based Definition and Model-Based Manufacturing. These processes involve a multi-level supply chain, using different CAD and CAM systems, and need to be operational during several decades. The applicable use cases are as follows:

- Use Case 1: Visual Interpretation and Visual Consumption
- Use Case 2: Feature-based Machining/Manufacturing
- Use Case 3: OEM Submission of Technical Data Package to Authority for Certification
- Use Case 4: Statistical Process Control

Selected Standards

The key standards define information models and formats for data exchange, visualization, and long-term archiving of CAD 3D model-based definitions. The following list of standards is requested to be implemented by the PLM solution providers:

- **ISO 10303-242** “Managed model-based 3D engineering” for CAD neutral data format exchange and long-term archiving (Note: AP203 and AP214 have been merged into AP242.)

- **ISO 14306** “JT file format specification for 3D visualization” for 3D lightweight visualization (Note: GITf (GL Transmission Format) could be an alternate to ISO 14306 JT for visualization.)
- **ISO 32000** “Portable Document Format (PDF)” / **ISO 14739** “3D use of Product Representation Format (PRC)” for 3D lightweight format visualization

The AD PAG requests that PLM solution providers and integrators implement the following standards in their OOTB solutions and participate in the related interoperability forums listed below:

- For **ISO 10303-242** : CAx IF¹⁹ and EWIS IF²⁰
- For **ISO 14306** : JT IF²¹
- For **ISO 32000 / ISO 14739** : 3D PDF IF²²

The table of main standards related to the AD PAG MBD and BOM Project Team (working group) and the recommendation status follows:

Table 1 - Main Standards for the MBD and BOM Project Team (Working Group)

Category	Standard	Version	Name	Status
Process	ASME Y14.41	2019	Digital Product Definition Data Practices	In Evaluation
Process	ASME Y14.5	2018	Dimensioning and Tolerancing	In Evaluation
Process	ISO 1101	2017	Geometric product specification (GPS) - Geometrical tolerancing	In Evaluation
Process	ISO 16792	2021	Technical product documentation - Digital product definition data practices	In Evaluation
Process	ISO 17599	2015	Technical product documentation - General requirements of digital mock-up for mechanical products	In Evaluation
Process	NAS /EN9300-1XX		Long Term Archive & Retrieval of Technical Product Documentation such as 3D, CAD and PDM Data	In Evaluation
Process	NAS /EN9300-3XX		Long Term Archive & Retrieval of Technical Product Documentation such as composite design information	In Evaluation
Process	NAS /EN9300-4XX		Long Term Archive & Retrieval of Technical Product Documentation such as electrical wiring harness information	In Evaluation
Process	ISO 13584	2001	Parts library	In Evaluation
Process	ISO 8000	2011	Data quality	In Evaluation
Process	ISO 23247	2021	Digital Twin framework for manufacturing	In Evaluation
Data	IEC 61360	2021	IEC Common Data Dictionary	In Evaluation
Data	ISO 14649	2003	Physical device control - Data model for computerized numerical controllers	In Evaluation
Data	ISO/ASTM 52915	2016	Specification for Additive Manufacturing File Format (AMF)	In Evaluation
Data	ISO 32000	2020	Portable document format (PDF)	Recommended
Data	ISO 13399	2006	Cutting tool data representation and exchange	In Evaluation
Data	ISO 23952	2020	Quality information framework (QIF) - An integrated model for manufacturing quality	In Evaluation
Data	ISO 10303-238	2020	STEP Part 238: Application protocol: Model based integrated manufacturing	In Evaluation
Data	ISO 10303-242	2020	STEP Part 242: Application protocol: Managed model-based 3D engineering	Recommended
Data	ISO 14739	2014	3D use of Product Representation Compact (PRC)	Recommended
Data	ISO/IEC 19775	2013	Computer graphics, image processing and environmental data representation - Extensible 3D (X3D)	In Evaluation
Data	ISO 14306	2017	JT file format specification for 3D visualization	Recommended

Selection Rationale

The standards are already widely used by the A&D industry and are partially implemented by the PLM providers. Yet, effort must be made to extend the standards’ functional scope.

Multi-View BOM

The main role of this team is to compare and contrast single- and multi-view BOM, and to agree on a set of standard solution constructs to address the complexities of multi-view BOM while enabling its benefits.

¹⁹ CAx IF : https://www.cax-if.org/cax/cax_introduction.php

²⁰ EWIS IF: https://www.cax-if.org/ewis/ewis_introduction.php

²¹ JT IF: <https://www.prostep.org/en/projects/jt-implementor-forum/>

²² 3D PDF IF: <http://3dpdfconsortium.org/implementor-forum/>

Business Values

The business values of the Multi-View BOM team are to support:

- Bi-directional collaboration between the OEM and the Manufacturing suppliers
- Communication within the manufacturer, particularly between its PDM system, its Enterprise Resource Planning (ERP) system, and its Customer Support Management system

For more details, refer to the detailed use cases described in the *Multi-View Bill of Materials* position paper available at <https://www.cimdata.com/en/aerospace-and-defense/publications>.

Selected Standards

The following key standards (both harmonized) are requested to be implemented by the PLM solution providers:

- **ISO 10303 AP242 ed2** “Managed model-based 3D engineering”
- **ISO 10303 AP239 ed3** “Product life cycle support”

These standards define information models and formats for data exchange, visualization, and long-term archiving of PDM information (configured multi-views product structure and BOM). The AD PAG requests that the PLM providers and integrators implement these standards in their OOTB solutions and participate in the PDM Interoperability Forum²³.

The table of main standards related to the AD PAG Multi-View BOM Project Team (working group) and the recommendation status follows:

Table 2 - Main Standards for the Multi-View BOM Project Team (Working Group)

Category	Standard	Version	Name	Status
Process	SAE ANSI/EIA 649	C	Configuration Management Standard	In Evaluation
Process	EN 9223	2018	Programme Management - Configuration Management	In Evaluation
Process	ISO 10007	2017	Quality Management - Guidelines for configuration management	In Evaluation
Process	IEC 81346	2009	Structuring principles and reference designations	In Evaluation
Process	IEC/EN 62890	2020	Life-cycle-management for systems and components	In Evaluation
Process	ISO 17599	2015	General requirements of Digital Mock-Up for mechanical products	In Evaluation
Process	NAS-EN9300-200	2017	Fundamentals and Concepts for Long Term Archiving and Retrieval of Products Structure Information	In Evaluation
Process	ISO 16792	2021	Technical product documentation - Digital product definition data practices	In Evaluation
Services	OAGI OAGIS	10.3	Open Application Group Integration Specification	In Evaluation
Data	SAE EIA 836B	2015	Configuration Management Data Exchange and Interoperability	In Evaluation
Data	ISO 10303-242	2020	STEP Part 242: Application protocol: Managed model-based 3D engineering	Recommended
Data	ISO 10303-239	2012	STEP Part 239: Application protocol: Product life cycle support	Recommended

Selection Rationale

The two recommended standards provide sophisticated mechanisms that address all the general needs for exchange and long-term archiving of configuration management data, including implicit definition by specification / options and explicit definitions by batch and date. The standards cover the full product lifecycle, including as specified, as designed, as planned, as built, as delivered, as operated product structure, etc.

These standards have been developed by prominent aerospace and automotive manufacturers, with an emphasis on the synergies and harmonization between different industries. The development of interfaces is tested by various PDM Interoperability Forums. The standards are recommended by both the AIA BTIC and the ASD SSG organizations.

²³ PDM IF : PDM ID: <http://www.pdm-if.org/>

Global Collaboration

A major business challenge of the Global Collaboration team is to achieve OEM and supply chain collaboration through bi-directional exchange of Technical Data Packages (TDPs) via digital tools and model-based processes.

Business Values

Common processes and principles shared world-wide by the industries to set up collaboration processes and principles between OEMs and their supply chains—from the initial discussions until the end of the contract—do not exist today. The Global Collaboration team would like to change the way that industries collaborate by using standards as the foundation of the future collaboration process.

Currently, every OEM uses its own, unique methodology, which includes OEM-specific vocabulary and milestones during the lifecycle of their products. This creates a major expense for the supplier because the supplier must provide data that meets the OEM’s requirements and methodology. This effort usually involves converting and sending data to meet the requirements or setting up a local OEM environment where the data is created, shared, and stored. Consequently, a supplier may be required to have multiple collaborative environments available to meet each OEM’s unique requirements.

If platform providers’ solutions were open and they adhered to industry, national, and international standards, interoperability would be less resource intensive and less error-prone, and collaboration could occur without setting up multiple supplier/customer environments.

Selected Standards

The following key standards are recommended to be implemented by the A&D industry and its supply chains to define common principles and the framework to set up, utilize, and optimize collaboration between A&D OEMs and their suppliers.

- **ISO 44001:2017** “Collaborative business relationship management systems - Requirements and framework” as generic principles for collaboration between OEMs and between OEMs and their supply chain
- **ISO 44002-2019** “Collaborative business relationship management systems: Guidelines on the implementation of ISO 44001”
- **ISO 11354-1-2011** “Requirements for establishing manufacturing enterprise process interoperability Part 1: Framework for enterprise interoperability.
- **Mil Std 31000B-2017** This standard provides requirements for the deliverable data products associated with a Technical Data Package (TDP) and its related TDP data management products. A TDP contains elements, is described by level and type, and may have associated meta data and supplementary technical data. A TDP contains a sub-set of product data and product data is a sub-set of technical data.

The table of main standards related to the AD PAG Global Collaboration Project Team (working group) and the recommendation status follows:

Table 3 - Main Standards for the Global Collaboration Project Team (Working Group)

Category	Standard	Version	Name	Status
Process	ISO 11354	2011	Requirements for establishing manufacturing enterprise process interoperability	In Evaluation
Process	ISO 11354-2	2015	Requirements for establishing manufacturing enterprise process interoperability - Maturity model for assessing	In Evaluation
Process	ISO 37500	2014	Guidance on outsourcing	In Evaluation
Process	ISO TR44000	2019	Principles for successful collaborative business relationship management	In Evaluation
Process	ISO 44001	2017	Collaborative business relationship management systems - Requirements and framework	Recommended
Process	ISO 44002	2019	Collaborative business relationship management systems - Guidelines on the implementation of ISO 44001	Recommended
Process	ISO 44003	2021	Collaborative business relationship management systems - Guidelines for micro, small and medium sized enterprises on the implementation of the fundamental principles	In Evaluation
Process	ISO 44004	2021	Collaborative business relationship management systems - Guidelines for large organizations seeking collaboration with micro, small and medium sized enterprises	In Evaluation
Data	MI Std 31000	2018	Provides requirements for the deliverable data products associated with a technical data package (TDP) and its related TDP data	In Evaluation

Selection Rationale

These standards cover the general principles and main process steps defined for complex collaboration projects. Use of these standards would ease alignment of the different manufacturers and their supply chains on a common framework. Their use would also help with the development of OOTB platforms for collaboration.

Model-Based Systems Engineering (MBSE)

This team was assembled to evaluate current data interoperability standards intended to enable an MBSE conceptual design process. The activity was to assess the feasibility of exchanging digital models, instead of documents, between A&D OEMs and their supply chain partners.

Business Values

The standards that support the MBSE paradigm define a path to neutral formats supporting design collaboration, data exchange, long-term archiving, RFL (Requirements, Functional, Logical) authoring, and integration between domains.

These processes involve multi-level supply chains, using different MBSE systems, and supporting product designs with lifecycles measured in decades. The following use cases have been addressed by the project team and are informed by the standards identified.

- Use Case 1: Product operational (mission level) definition
- Use Case 2: Requirements allocation and decomposition
- Use Case 3: Transformation of functional architectures to physical implementations
- Use Case 4: The design and integration of complex distributed network-enabled systems

Selected Standards

The following key standards are requested to be implemented by the PLM solution providers:

- **MODELICA FMI** – Functional Mock-up Interface (exchange and co-simulation Functional Mock-up Units (FMU))
- **MODELICA SSP** – System Structure Parameterization (packaging FMUs)

- **ISO 10303-243**²⁴ “Modeling and simulation information in a collaborative systems engineering context (MoSSEC) for the communication / annotating / sharing of metadata associated to models (metadata viewer and editor)”
- **ISO 42010** “Architecture Description Language (ADL) application (SysMLv2 or Arcadia, and OPM)”
 - Canonical XMI for consistent definition of the data across ADLs
 - UMLDI (UML Diagram Interchange) import and export to enable ADL interoperability
- **ReqIF** (Requirements Interchange Format), file generator and editor
- **ISO/IEC 8632** “Computer Graphics Metafile (CGM)²⁵ for schematics and graphical output”

The AD PAG requests that the PLM solution providers implement these standards in their OOTB solutions and also participate in the related interoperability forums.

The table of main standards related to the AD PAG MBSE Project Team (working group) and the recommendation status follows:

Table 4 - Main Standards for the MBSE Project Team (Working Group)

Category	Standard	Version	Name	Status
Process	ISO/IEC 19514	2017	Object management group systems modeling language (OMG SysML)	Recommended
Process	ISO/IEC 15288	2015	Systems and software engineering - System life cycle processes	Recommended
Process	ISO/IEC/IEEE 29148	2018	Systems and software engineering - Life cycle processes - Requirements engineering	In Evaluation
Process	ISO/IEC 24748	2018	Systems and software engineering - Life cycle management	In Evaluation
Process	SAE ARP 4754	A	Guidelines for Development of Civil Aircraft and Systems	In Evaluation
Process	ISO/IEC/IEEE 42010	2011	Systems and software engineering - Architecture description	In Evaluation
Process	ISO/IEC/IEEE 42020	2019	Software, systems and enterprise - Architecture processes	In Evaluation
Process	ISO/IEC/IEEE 42030	2019	Software, systems and enterprise - Architecture evaluation framework	In Evaluation
Process	SAE AS 5506	C	Architecture Analysis & Design Language (AADL)	In Evaluation
Process	OMG UAF	1.1	Unified Architecture Framework	In Evaluation
Process	AIA/NAS 9300-500	2020	Fundamentals and Concepts for long term archive and retrieval of Model-Based Systems Engineering information	In Evaluation
Data	OMG ReqIF	1.2	Requirements Interchange Format	Recommended
Data	MODELICA FMI	2.0.2	Functional Mock-up Interface	In Evaluation
Data	ISO 10303-233	2012	STEP Part 233: Application protocol: Systems engineering	Recommended
Data	ISO 10303-239	2012	STEP Part 239: Application protocol: Product life cycle support	In Evaluation
Data	ISO 10303-242	2020	STEP Part 242: Application protocol: Managed model-based 3D engineering	In Evaluation
Data	ISO 10303-243	2021	STEP Part 243: Application protocol: For modelling and simulation information in a collaborative systems engineering context (MoSSEC)	Recommended

Selection Rationale

The industry’s transition to electric-powered, software-driven platforms has increased the number of suppliers and the associated integration requirements. Diverse authoring environments combined with the increased number of required tools have added complexity to the conceptual design process. The text-based acquisition process no longer supports management of the requirements, architecture, and validation criteria. Digital modeling methods are the only path to deterministic computational simulations and product qualification.

²⁴ ISO 10303-243 is currently in development by an international team of experts and its release is forecast for Q4 2021. In addition, ISO 10303-18 enables a set of web services and extensions that are required for the proper implementation of ISO 10303-243.

²⁵ CGM profiles are continuously enhanced to enable new technologies in web viewing and visualization. Scalable Vector Graphics (SVG) is also a de facto standard utilized for visualization of schematics and are commonly used.

Go Forward Plan

Based on the foundation established by three direction statements for process and data standards published in 2017:

- Product Manufacturing and Information (PMI) - Direction Statement
- Data Upward Compatibility - Direction Statement
- Product Data Exchange Standards - Direction Statement

They can be accessed via the following link: <https://www.cimdata.com/en/aerospace-and-defense/publications/standards>.

This paper summarizes the position as a group and outlines a specific set of recommended standards focused on the interoperability of product data across the product lifecycle.

Edition 1 covers the initial scope of fifteen standards, focused on the key priorities of the AD PAG project teams (working groups) and as identified in 2019 through 2020. The next editions will extend progressively the list of interoperability standards based on the new requirements of the AD PAG teams. The ultimate objective is to support the digital thread in the Model-Based Enterprise and the new ways of working based on the introduction of the digital twins, methods of implementation (web services, micro services, etc.), and ontologies.

In a future edition to this position paper, additional topic areas will be addressed, including:

- Extension of this position paper’s scope,
- Implementation of PLM software,
- Deployment by the A&D industry,
- Requirements to standardization bodies,
- Requirements to interoperability forums, and
- Recommendations to aerospace trade associations.

PLM Software Implementation

To address the business requirements summed up in the *Business Requirements for PLM Interoperability* section, the A&D industry needs its solution providers to support the following list of the fifteen key interoperability standards defined in Edition 1 of this document.

- ISO 10303-242 “Part 242: Application protocol: Managed model-based 3D engineering”
- ISO 14306 “JT file format specification for 3D visualization”
- ISO 32000 “Portable Document Format” (PDF)”
- ISO 14739 “3D Use of Product Representation Format (PRC)”
- ISO 10303 AP239 ed3 “Part 239: Application protocol: Product Life Cycle Support”
- ISO 44001:2017 “Collaborative business relationship management systems - Requirements and framework”
- ISO 44002-2019 “Collaborative business relationship management systems - Guidelines on the implementation of ISO 44001”

- ISO 11354-1-2011 “Requirements for establishing manufacturing enterprise process interoperability Part 1: Framework for enterprise interoperability”
- Mil Std 31000B-2017 “Military standard - Technical Data Package (TDP)”
- MODELICA FMI “Functional Mock-up Interface”
- MODELICA SSP “System Structure and Parameterization”
- ISO 10303-243 “Part 243: Application protocol: For modelling and simulation information in a collaborative systems engineering context (MoSSEC)”
- ISO 42010 “Systems and software engineering - Architecture description”
- ReqIF “Requirements Interchange Format”
- ISO/IEC 8632 “Computer graphics - Metafile for the storage and transfer of picture description information”

Many of the minimum requirements for these PLM interoperability standards have started to be implemented in the commercial product solutions from the PLM solution providers; yet these COTS standards interfaces must be tested by the related interoperability forums to speed their deployment with the appropriate level of quality. The AD PAG urges the solution providers to include in their implementation plans the missing capabilities of the selected standards. A regular progress report will be presented by the PLM providers to the AD PAG.

AD PAG members will view PLM solution providers who provide implementation and support of the PLM interoperability standards listed above as **demonstrating an advantage in compliance with A&D business requirements**.

Industry Deployment

This position paper helps the A&D industry identify common standards of high business value to be requested of the PLM providers and integrators and to be used in operation within the companies and with their supply chains. To take advantage of these recommended standards that address the principles, terms, data exchange, and visualization, the A&D industry and its supply chains must deploy the standards as soon as possible, when appropriate.

The success of this position paper and its influence for future editions will be related to the speed and quality of implementation by PLM providers and by deployment in A&D industry operations.

Requirements to Standardization Bodies

The AD PAG will provide requirements to the standardization organizations for the missing capabilities in this initial list of standards and will contribute, via its member company participants, to the related standards roadmap preparation.

The AD PAG will ensure appropriate coordination with the A&D trade associations in charge of recommendations for PLM standards governance to maximize the synergies benefits and accelerate acceptance of the standards’ broad operation uses.

Requirements to Interoperability Forums

The AD PAG will engage with established interoperability forums, such as the MBx Interoperability Forum, to prioritize test rounds with a focused list of requirements from the A&D member companies. The AD PAG will continue to extend the list of requested standards supported

by the interoperability forums, according to the AD PAG project teams’ progress and requirements lists.

Recommendations to Aerospace Trade Associations

This AD PAG position paper’s content will be contributed to similar research endeavors carried out by specific organizations of American and European aerospace trade associations, such as the AIA Business Technology Interoperability Council (BTIC)²⁶ and the ASD Strategic Standardization Group (SSG)²⁷, ensuring standards recommendation sharing based on the scope of common interest. This effort will maximize the standards’ affect and accelerate common standards deployment across all supply chains, including small- and medium-sized enterprises.

Appendix B: Introduction to the Standards Radar Screen describes the product of the trade associations, a so-called radar chart, that this position paper will inform.

²⁶ AIA BTIC : <https://www.aia-aerospace.org/committee/business-technology-interoperability-committee/>

²⁷ ASD SSG : <http://www.asd-ssg.org/>

About A&D PLM Action Group

The Aerospace & Defense PLM Action Group (www.ad-pag.com) is an association of aerospace and defense companies 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 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.

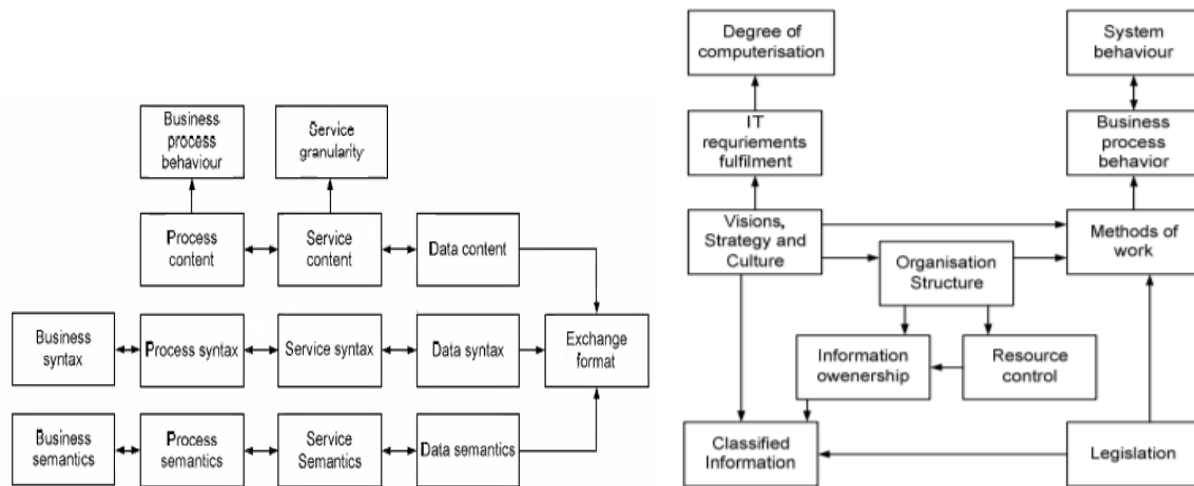
In addition to consulting, CIMdata conducts research, provides PLM-focused subscription services, and produces several commercial publications. The company also provides industry education through PLM certification programs, seminars, and conferences worldwide. CIMdata serves clients around the world from offices in North America, Europe, and Asia-Pacific.

To learn more about CIMdata's services, visit our website at www.CIMdata.com or contact CIMdata at: 3909 Research Park Drive, Ann Arbor, MI 48108, USA. Tel: +1 734.668.9922. Fax: +1 734.668.1957; or at Oogststraat 20, 6004 CV Weert, The Netherlands. Tel: +31 (0) 495.533.666.

Appendix A: Classification of Standards to Support Model-Based Enterprise Interoperability

The digitalization of the A&D industry results in an intensive usage of digital models and associated meta data instead of textual, 2D or 3D geometry documents, and notes. Most of an engineer’s activities are related to technical standards that are supported by OOTB applications. These activities result in communication between PLM applications within the A&D manufacturer and with the extended enterprise. To support this digital thread within the company and between companies, the approach defined in ISO 11354 “requirements for establishing manufacturing enterprise process interoperability, part 1 “Framework for enterprise interoperability” will be used.

Once the interoperability barrier cube is flattened to a 2D view, it may be represented as the following illustration showing the types of interoperability problems to be solved.



And the following table highlights short descriptions of the types of interoperability problems to be solved.

Id	Name	Description
C/D-1	Data content	Coverage, i.e. content, of the respective data representation
C/D-2	Data syntax	Heterogeneous data format and structure
C/D-3	Data semantics	Data meaning disagreements
C/S-1	Service content	Differences in the coverage, i.e. content, of the services offered
C/S-2	Service syntax	Language/formalism syntax used to describe the services
C/S-3	Service semantics	The meaning of services descriptions
C/P-1	Process content	Coverage, i.e. content, of the processes
C/P-2	Process syntax	Process description language grammar and graphical representation
C/P-3	Process semantics	The meaning of the processes description
C/B-1	Visions, strategies & Culture	Differences in the respective companies goals, views, etc.
C/B-2	Business syntax	Format, template or model used for describing enterprise business
C/B-3	Business semantics	Meaning of terms used to express business issues
T/D-1	Exchange format	Protocol or format available to exchange information
T/S-1	Service granularity	Definitions of what constitutes the services, i.e. interface problems

T/P-1	Process behavior	Order of operations in the computerized processes
T/B-1	Degree of computerization	How much of data, services and processes that are automated in IT
T/B-2	IT requirement fulfillment	The ability of IT to support the requirements of the business
O/D-1	Information ownership	The structures for assigning rights to data
O/D-2	Classified information	Differences in which information that is to be regarded as classified with respect to the collaboration partner
O/S-1	Resource control	The allocation of resources, technical as well as non technical.
O/P-1	Business process behavior	Order of operation in business processes
O/B-1	Legislation	The legislative requirements that influence different actors.
O/B-2	Organization structure	How enterprises are organized on a high level
O/B-3	Methods of work	High level differences regarding how work is performed in the organizations

Various standards can be classified into each of the rectangles/ barrier cubes, by noting a critical interoperability characteristic. The complexity inside a box should be solved within the box and

not cross over to the other box. This is the most fundamental enabler of interoperability. Interoperability in the business layer depends on interoperability within the bottom layers.

Click on the following link for a description about the Enterprise Interoperability Framework by David Chen:

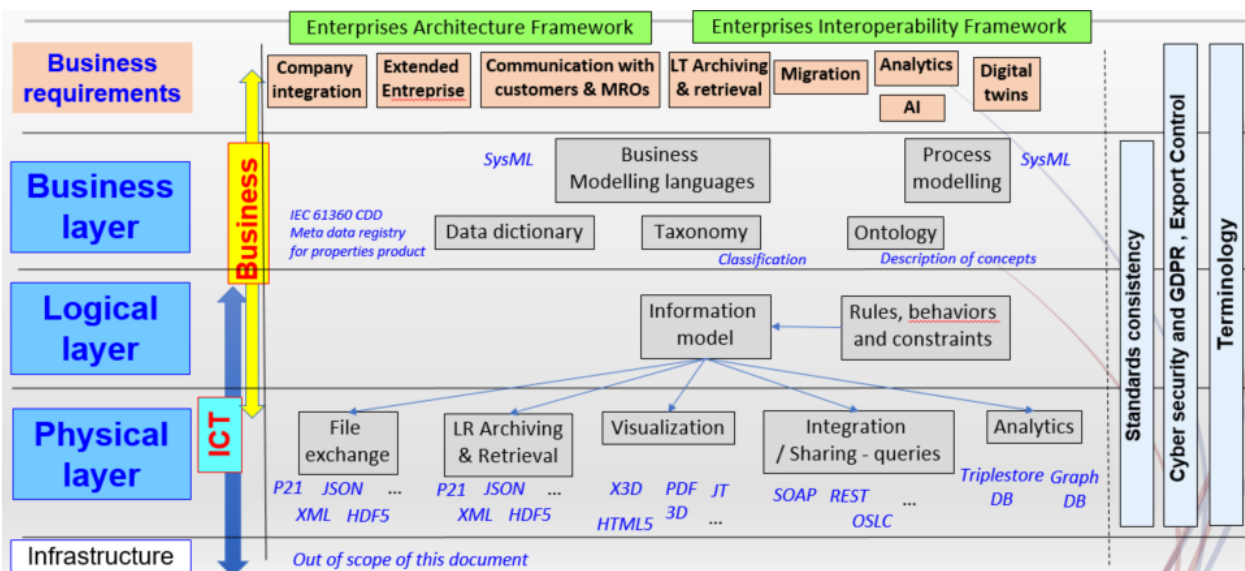
<http://citeseerx.ist.psu.edu/viewdoc/citations?doi=10.1.1.87.7959>

Context

Another PLM interoperability template (view) is proposed to illustrate the links between the business requirements and the resulting information system solutions to be used through a layer approach.

The view is relevant for all technical business disciplines and all product lifecycle stages due to increasing requests for efficient, technical information processing of greater complexity and increasing volume within a shorter timeframe that covers the full bi-directional product lifecycle.

The following figure highlights the importance of strong coordination between the business organization and the Information Systems/Information and Communication Technology specialists.



Generic Business Requirements for PLM Interoperability Capabilities

In the figure, the Business Requirements layer captures the high-level business requirements for PLM interoperability of the A&D manufacturer that must develop, manufacture, and support a product and services. This layer is based on the requirements described in the *Business Requirements for PLM Interoperability* section.

Business Layer

The business layer involves technical standards to be considered by those involved in product development, manufacturing, and support. Initially, the technical standards were documents-based, and they are becoming increasingly digital-model-based (SMART standards).

This layer includes principles, activities and processes, terms and dictionaries, requirements (industry, regulations, etc.), taxonomy and associated properties, modelling languages (e.g., SysML), quality rules and related key performance indicators, etc.

These technical standards will be progressively considered in PLM COTS applications as technical specifications to support the digitalization of the business activities.

Logical Layer

The logical layer mainly relies on the information models of the different technical disciplines that represent the different activities of the manufacturer. These information models are closely related to the terminology / dictionaries and to the related ontologies, in development in several industries. This layer involves different skills: business methods and tools specialists and information systems specialists.

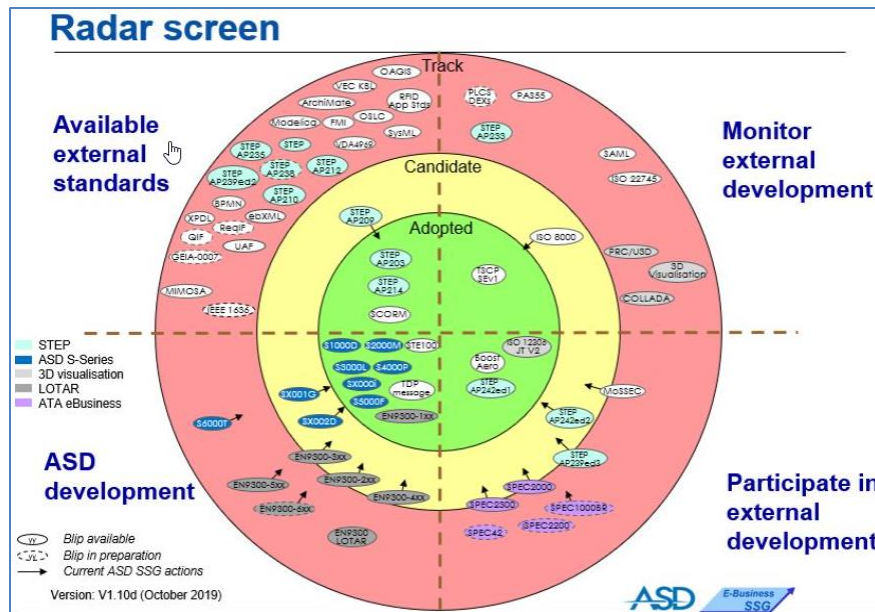
These information models may be isolated (i.e., developed in “silos” with potential overlaps and inconsistency) or integrated.

Physical Layer

This layer is closely related to the information system, such as legacy systems, OOTB applications, complementary in-house development, and integrators’ solutions; it takes into account the information technology capabilities and constraints that evolve rapidly through time to optimize the requested functions’ implementation.

Appendix B: Introduction to the Standards Radar Screen

The principles of the standards radar screen were defined in the early 2000s by the AIA Business Technology Interoperability Council (BTIC)²⁸. Since 2008, the standards radar screen has been used by the ASD SSG²⁹.



For the manufacturers' association managing this component standard radar chart, the main objectives are to allow the following:

- Monitoring the appropriate level of effort of the manufacturer's association in the development of a standard:
 - Adopt existing standard
 - Monitor external development
 - Participate in external development
 - Development
- Identifying the level of support for the standard by the manufacturers' association:
 - Potential candidate standard
 - Candidate standard
 - Adopted standard

Link to the current radar chart of the AIA BTIC is available at <https://www.aia-aerospace.org/wp-content/uploads/2016/05/BTIC-radar-chart-end-of-2015.pdf>.

Link to the current radar chart of the ASD SSG is available at <http://www.asd-ssg.org/radar-chart>.

²⁸ AIA BTIC: <https://www.aia-aerospace.org/committee/business-technology-interoperability-committee/>

²⁹ ASD SSG: <http://www.asd-ssg.org/>