

# *PLM Global Collaboration*

---

Problem Statement, with Use Cases, and Go Forward Plan

Release 1.0

June 2019



**AEROSPACE & DEFENSE PLM ACTION GROUP**

## Abstract

---

Collaboration among Original Equipment Manufacturers (OEMs) and their product design and manufacturing engineering partners and suppliers is a key aspect of any major Aerospace and Defense (A&D) program execution. This paper explores the need to enable frictionless operation between OEMs and their suppliers. Process analysis by the A&D PLM Action Group (AD PAG) project team has shown that many different data formats, PLM software systems, and enabling infrastructure technologies exist across the OEMs and their supply base. This position paper, in its first release, presents the problem statement, including use cases, and the project team’s go forward plan. Future releases will include a statement of business performance improvement objectives, a description of the desired future state, and requirements by which that future state can be achieved.

Current research focuses on the complex data flow process during initial design, detailed design, configuration control, and change management. Collaboration during build and post-production will be addressed in a later phase of the project team’s research, and the AD PAG vision for “Collaboration in the 21<sup>st</sup> Century” will be presented in a future publication.

# Table of Contents

---

Revision Record .....	3
Executive Summary.....	4
Introduction.....	4
Problem Statement.....	5
Context.....	5
Use Cases.....	5
Use Case 1: Exchange of Product Data.....	8
Use Case 2: Work Assignment and Design Delivery .....	12
Use Case 3: Asynchronous Design and Evaluation.....	13
Use Case 4: Design Review and Approval .....	14
Use Case 5: Digital Mock-Up .....	16
Use Case 6a: Managing Configuration and Change Control of the Product Data .....	18
Use Case 6b: Managing Configuration and Change Control of the Data Package.....	20
Business Consequences.....	21
Causal Analysis.....	21
Exchange .....	21
Conversion Validations.....	22
Reconversion Validations.....	22
Framework .....	22
Governance.....	23
Go Forward Plan .....	23
About A&D PLM Action Group.....	24
About CIMdata.....	24

# Revision Record

---

<b>Revision</b>	<b>Date</b>	<b>Description</b>
<b>1.0</b>	<b>June 2019</b>	Initial Release (Phase 1)

# *PLM Global Collaboration*

## **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 manufacturers within CIMdata's globally recognized PLM Community Program, which functions as a PLM advocacy group. One of the key business issues (i.e., pain points) identified by this industry group is that collaboration within a large, global, distributed supply chain of design and development partners is seriously hindered by relying on traditional, document-based development processes. As such, a major business challenge identified by the group is to **achieve OEM and supply chain collaboration through bi-directional exchange of Technical Data Packages (TDP) via digital tools and model-based processes.**

In response, a project team of domain experts from the AD PAG member companies was established to evaluate current collaboration practices. Here, collaboration is defined as a set of data standards and work processes used to share and work with product data. Traditional asynchronous data exchange is described with all the pros and cons, including those of the Digital Mock-Up (DMU) during the entire product development lifecycle, including engineering change control.

This Phase 1 version of the *PLM Global Collaboration* position paper addresses multiple current state use cases and includes detailed descriptions and challenges for each. Business consequences and analysis of the root cause of current collaboration problems, as well as a Go Forward Plan, are described. As the AD PAG's research continues, Phases 2 and 3 will offer objectives, a description of the desired state, and specific recommendations and requirements to help the A&D industry reach its goal of simplified PLM global collaboration.

## **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 would lead to consensus on priorities and plans for remediation of their common PLM pain points. These discussions resulted in agreement of the members 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 special project, which was initiated in 2017, is **PLM Global Collaboration**. Since the initial agreement, AD PAG membership has increased from five to eleven OEMs, including Bombardier, Dassault Aviation, GE Aviation, Mitsubishi Regional Jet, Pratt & Whitney, and Safran, and this particular project team has added subject matter experts (SMEs) from many of them.

The global collaboration pain point of friction, complexity, and/or instability erodes the productivity and quality of product information flow through A&D system programs and inflates the cost of system sustainability. The overall scope of the **PLM Global Collaboration** project is

to provide templates for a data integration/exchange setup and process and practice protocols consistent with industry standards. This document details the mechanics of configuring and integrating a supplier in an ideal/optimal/desired state. The intent is that this position paper will aid OEMs in setting up contracts with their suppliers.

The scope of the first phase of this position paper focuses on the data flow process during initial design, detailed design, configuration control, and change management. These areas within the overall product development process were identified as offering the most potential for improvement in earlier stages of the Global Collaboration project and were described in the project's first position paper (research report). This second position paper defines a baseline for current processes and standards. Project Phases 2 and 3 for this paper will develop objectives, a description of the desired state and specific recommendations, and a set of requirements for a future approach to global collaboration.

## Problem Statement

---

This section of the position paper identifies, through current state use cases, the common roadblocks that limit simple, rapid, and reliable OEM PLM to design partner PLM data exchange for Digital Mock-Up (DMU) in the A&D industry today. Each use case is presented in table format that includes the use case name, description, actors involved (by general title), challenges, and preconditions/prerequisites.

## Context

The exchange of Product Data Management (PDM) to PDM Computer-Aided Design (CAD) and Bill of Materials (BOM) data within the A&D industry among airframers, engine manufacturers, and other partner companies can best be described as tedious. Each company has different PLM software systems, versions, and customizations, and also different CAD software systems and versions. Exchanging data between any two companies requires bi-directional agreements of exchange—how to handle errors and expansion of the exchange process, as well as how to protect Intellectual Property (IP) data. No single standard for either CAD or PLM data exchange exists. Therefore, each company is required to agree on a CAD and PLM proprietary data format or a neutral format, naming and revision schemes, configuration control, and how to provide synchronization of the data between the two companies. This leads to lost time and slowed deliverables as each company works to establish the basis for an exchange. Each company has its own exchange requirements; therefore, exchanging data requires independent and exclusive processes, each unique and complicated, in an effort to support the long-term future of collaboration.

## Use Cases

This initial phase of the Global Collaboration project has been limited to the process of data flow during initial design, detailed design, configuration control, and change management of data. The concepts behind the use cases have been conceived and arranged to form a collaborative process environment in which the tasks of the work, such as work content (contracts), design, and review, are undertaken within the controls of configuration and change management and supported by the DMU (Model Based) which are serviced by a data exchange activity (illustrated in Figure 1). These use cases and associated data types represented serve as examples and demonstrate the issue

where OEMs and suppliers are working on disparate and disconnected systems. The associated and documented data types in this section will not be the only data types addressed in the desired state (recommendations) portion of this paper's Phase 2 version.

The following current state use cases (i.e., As Is scenarios) are intrinsically linked and interact with each other, utilizing a common set of data.

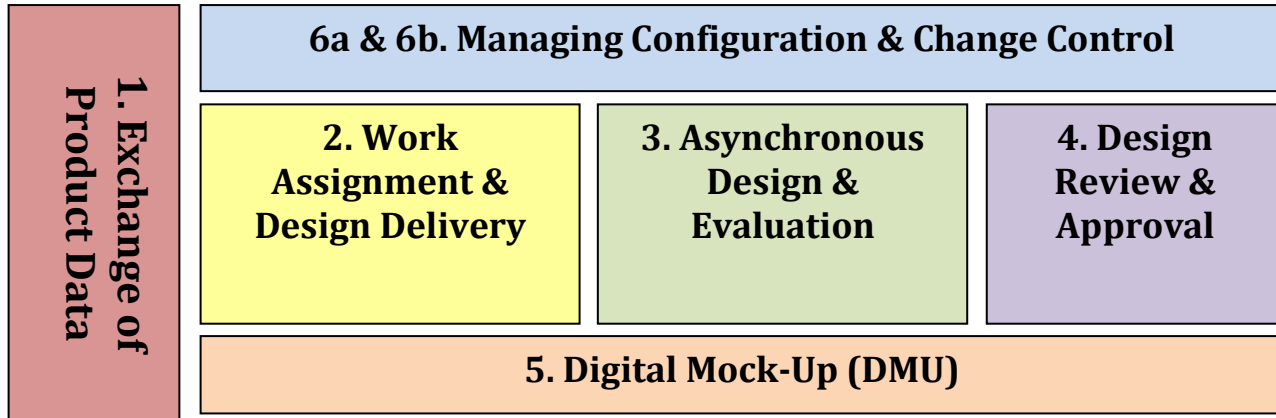


Figure 1 - Current State Use Cases Intrinsically Linked and Using a Common Set of Data and Activities

- **Exchange of Product Data** is the activity to Extract, Transform, and Load (ETL); that is, first extract data from the source system, if needed convert the data to the target system, and at the end integrate the data into the target system. Such data exchange could be done for different types of data (e.g., CM, CAD, DMU, etc.) and during different phases of the product lifecycle. Normally, the source and target are at different locations, and a TDP is used to transfer the data. A data exchange is always an asynchronous process. The several steps should be controlled and, mainly in case of conversion, validation should be done.
- **Work Assignment and Design Delivery** encompasses the information and data required to do the following:
  - Enable the definition of the work content, timescales, and costs for the product deliverables
  - Set up the exchange, control, and change mechanisms that enable the work to be undertaken
- **Asynchronous Design and Evaluation** involves providing the data and information (i.e., engineering methods, requirements, and rules) to enable a fully engineered solution for a product, which has been evaluated and validated as fit for purpose against a set of requirements.
- **Design Review and Approval**
  - **Design Review** ensures that the proposed product solution satisfies the agreed upon requirements, customer expectations, and specifications with due regard to an optimized design, considering safety, performance, cost, reliability, maintenance, and ease of manufacture.
  - **Approval** is the formal acceptance by the Technical Authorities/Experts that the engineering solution has met all requirements. The collaboration between OEMs and suppliers provides enough information and data to successfully conduct a specific review.
- **Digital Mockup (DMU)** is a 3D representation of a precise, complete assembly and interfacing hardware, including partner/customer parts, tooling, instrumentation, keep out zones, and other

modeling that can be visualized using 3D CAD software or integrated into a target PLM system. The DMU consists of geometrical representations of the product, resources, or production environment (preferably lightweight 3D data) to enable integration into a target PLM system. Usually, this implies conversion activities for 3D and structural data.

- **Managing Configuration and Change Control** is essential to ensure that all information used by both OEMs and suppliers is understood in terms of its completeness, standard, status, revision, and relevance for the product. This can be considered in two parts: first, the rules to control the product data and its standing as part of the product (e.g., naming, effectivity, etc.) and second, the control of the data packages transferred between parties, such as the data standard and its status etc.

The seven specific As Is use cases addressed in this section are as follows:

1. Exchange of Product Data
2. Work Assignment and Design Delivery
3. Asynchronous Design and Evaluation
4. Design Review and Approval
5. Digital Mock-Up
- 6a. Managing Configuration and Change Control of the Product Data
- 6b. Managing Configuration and Change Control of the Data Package

For easy reference each use case begins on a separate page.

### Use Case 1: Exchange of Product Data

The current method/activity for sending or receiving engineering information is via the Data Exchange process.

1. Exchange of Product Data (As Is)	
<b>Use Case Name</b>	Exchange of Product Data
<b>Description</b>	<p><b>Manage the request of export of all data from an OEM to a supplier:</b></p> <p>The export of CAD data from the PDM system to suppliers is triggered by a data exchange request. After the request is analyzed, the data is extracted from the PDM vault or from the folder to a local file system.</p> <p>Afterwards, a packaging process is performed. The resulting TDP is delivered to the supplier in an adequate format on the agreed upon exchange medium, which could be a server or storage medium. A notification email is sent to confirm the sent information.</p> <p>This process may be executed manually or with full or partial automation.</p> <ul style="list-style-type: none"> <li>• Request to send from user</li> <li>• Data extraction</li> <li>• Data conversion (if required)                             <ul style="list-style-type: none"> <li>– CAD conversion formats (or neutral)                                     <ul style="list-style-type: none"> <li>▪ 2D</li> <li>▪ 3D</li> </ul> </li> <li>– Product Manufacturing Information (PMI), including Geometric Dimensioning &amp; Tolerancing (GD&amp;T), notations, and views</li> <li>– Attribute data</li> <li>– Documents</li> </ul> </li> <li>• Quality check</li> <li>• Package data</li> <li>• Notify and send to receiver</li> </ul> <p><b>Request the import of all data from a supplier to an OEM:</b></p> <p>The On Request import of CAD and PDM data from another supplier into the PDM system is a manual process. The exchange is triggered by a data exchange request for the sender. The sender delivers an On Demand TDP, which is integrated into the PDM system. A CAD conversion is done for non-convenient native formats, and a product structure conversion is done from supplier to PDM. A data quality check secures the import of valid CAD models. To ensure the correct geometry after conversion, it is a requirement to <b>manually check</b> for any errors.</p>

<b>1. Exchange of Product Data (As Is)</b>	
<b>Use Case Name</b>	Exchange of Product Data
	<ul style="list-style-type: none"> <li>• Request from OEM/supplier</li> <li>• Notification and receipt of package from sender</li> <li>• Data extraction</li> <li>• Data conversion (if required)                             <ul style="list-style-type: none"> <li>– CAD conversion formats (or neutral)                                     <ul style="list-style-type: none"> <li>▪ 2D</li> <li>▪ 3D</li> </ul> </li> <li>– PMI, including GD&amp;T, notations, and views</li> <li>– Attribute data</li> <li>– Documents</li> </ul> </li> <li>• Quality check</li> <li>• Data integration into PDM</li> <li>• Notification to receiving user</li> </ul>
<b>Actors</b>	Designer(s) and Data Exchange Expert(s)
<b>Challenges</b>	<ul style="list-style-type: none"> <li>• Bi-directional agreement</li> <li>• Asynchronous exchange</li> <li>• Data conversion errors</li> <li>• Data size and growth</li> <li>• IP data protection</li> <li>• Connectivity optimization</li> <li>• Leveraging best practices</li> </ul> <p>(See descriptions below.)</p>
<b>Preconditions/ Prerequisites</b>	<ul style="list-style-type: none"> <li>• Data types</li> <li>• Connectivity</li> <li>• Exchange frequency</li> <li>• Data selection</li> <li>• Data formats</li> <li>• Conversion validation</li> <li>• Additional principles, including program and leadership support</li> </ul> <p>(See descriptions below.)</p>

### **Challenges Detail**

- **Bi-directional agreement.** When suppliers are working for multiple OEMs, this leads quickly to separate and independent systems installations and customization. The same data is exchanged multiple times due to several receivers or different formats, etc. This translates in to high costs for maintenance and support.
- **Asynchronous exchange.** As for data exchange, a package is generated, and the receiver is using this data asynchronously. On the sender side, development is still ongoing, and this presents a high risk that data within the TDP is very quickly out-of-date.
- **Data conversion errors.** Data conversion is not error-free. How to guarantee consistent and complete data is a continuous challenge. Each conversion needs to be validated with appropriate mechanisms, such as geometrical comparison of volume, surface, and center of gravity.
- **Data size growth.** Due to the evolution of CAD systems and the content managed within 3D data, the size of data is growing with each CAD release and also year by year.
- **IP data protection.** In most cases, only neutral data is exchanged, but as mentioned earlier, each conversion could introduce errors and create negative impacts, such as in geometrical differences or in assembly positioning. For several use cases, native/proprietary data may be requested for update and may not contain protection of IP. In addition, the exchanged data could be simplified by removing all inner geometry and exchanging only the outer shape (shrink wrap).
- **Connectivity optimization.** The limitations of current connectivity technology affect the speed and timeliness of data availability. Typically, the availability is agreed to by the two parties involved, and the data exchange is synchronized at the minimum standard, phased-dependent supplier integration level. This integration level is determined by the IT infrastructure supporting each participant. When a supplier is working for multiple OEMs, many connections of varying complexities are required and should be simplified and optimized as much as possible.
- **Leveraging best practices.** All data exchanges should take advantage of the industry best practices and standards used for collaborating between the sending and receiving parties. Exchanging parties should avoid creating new pathways by researching existing methods and coordinating with IT to manage the exchange.

### **Preconditions/Prerequisites Detail**

Before data exchange is launched, a bi-directional agreement between both partners—sender and receiver—needs to be defined and include answers to the following:

- **Data types.** The type of data that needs to be exchanged must be determined and agreed upon (e.g., CAD, visualization, 3D or 2D, metadata, etc.). Also, the development phase in which the data exchange is requested should be clarified (e.g., preliminary design, detailed design, in service, etc.). Different types of DMU data may be exchanged as preliminary design data, type design data, etc., but for better usage the data should be marked to indicate the data's lifecycle stage. This also makes it easier for the receiver to differentiate between read-only and modifiable data. In an ideal case, the modifiable data is locked in the sender system to avoid a parallel way of working. To enable better security, data should be classified in the system. However, special treatment may be required for export-sensitive data. The DMU is a representation of a specific deliverable that contains accurate interfaces and defines the space (volume) of the end product. The DMU product structure is not equivalent to the BOM. The BOM defines all of the components that are part of the physical product delivered to the end customer.

- **Connectivity.** The levels of collaboration are based on the connectivity between parties, must be agreed upon in the contract, and are determined by the volume, type, and nature of the data exchange necessary to undertake the activity. Depending on the connection needs and IT systems used by the collaborating companies, the exchange is currently operated via three methods: (S)FTP Transfer, Remote Access to OEM Environment/Host, or Local Access to OEM Environment/Host. All data exchanged should be completed using the latest, approved IT security protocols.
- **Exchange frequency.** The frequency of exchange must be defined, such as:
  - Once—one-time full extract
  - On a regular basis (frequency) and if regular—full or delta/incremental data (i.e., only data changed since the last extraction)
  - Event triggered, such as by a release process; for example, during the release process an export is launched to deliver the dataset (e.g., build-to-print supplier)
- **Data selection (e.g., subscription list, assembly tree walk, or zoning and boxing).** The data needing to be exchanged should be defined by part ID or assembly node or by a bounding box or geometrical.
- **Data formats.** Examples include proprietary CAD data (native CAD data), derived visualization data, and a converted neutral standard format (i.e., STEP, JT, IGES, DXF, etc.). In addition to conversion to a neutral data format, the data content should be protected by a mechanism that prevents exchange of a complete product break down, allowing only an envelope or shrink wrap and no inside geometry.
- **Conversion validation.** In the case of data conversion, all relevant model data needs to be validated for completeness and accuracy. A good example is the use of Geometric Validation Properties (GVP): before the conversion, calculate some values like volume and center of gravity, and then after conversion, recalculate the same values and compare the deviations. The allowable tolerance must be defined in the data exchange agreement.
- **Additional principles.** Two main principles that lead to data exchange can be distinguished—direct access (synchronous) and asynchronous. Asynchronous transfer currently offers two different options: Push and Pull mode and also whether a full send or a trickier incremental or delta exchange for the data exchange occurs each time. Due to security concerns, the infrastructure for such exchange or access should be located in a so-called *demilitarized zone (DMZ)* to better control internal and external access, etc. Instead of the DMZ, the infrastructure could be located in a private and secure Cloud. In addition, the TDPs could be encrypted to ensure better control of data access.

**Use Case 2: Work Assignment and Design Delivery**

This use case addresses the information and data required to enable the definition of the work content, timescales, and costs for the product deliverables, and to set up the exchange, control, and change mechanisms that allow the work to be undertaken.

<b>2. Data Exchange of Program and Project Data (As Is)</b>	
<b>Use Case Name</b>	Work Assignment and Design Delivery
<b>Description</b>	Set up the work activity between the OEM and the supplier <ul style="list-style-type: none"> <li>• Definition of the work activity (Statement of Work)</li> <li>• Contract definition and agreement</li> <li>• Bi-directional information transfer route definition–ability to log and record dates and versions/revisions</li> </ul> Monitor and manage the problems and issues
<b>Actors</b>	Program Manager(s), Engineering, and Procurement
<b>Challenges</b>	Agree to the work content, information transfer mechanisms, and process for solving issues and escalations.
<b>Preconditions/ Prerequisites</b>	<ul style="list-style-type: none"> <li>• Additional principles, including program and leadership support</li> <li>• Contractual agreements are in place, IT agreements</li> </ul>

***Preconditions/Prerequisites Detail***

Refer to *Use Case 1: Exchange of Product Data* for a description of the preconditions and prerequisites (e.g., data types, exchange frequency, data selection, etc.) common to this use case.

### Use Case 3: Asynchronous Design and Evaluation

As noted previously, Asynchronous Design and Evaluation involves providing the data and information (i.e., engineering methods, requirements, and rules) to enable a fully engineered solution for a product, which has been evaluated and validated as fit for purpose against a set of requirements.

<b>3. Asynchronous Design and Evaluation (As Is)</b>	
<b>Use Case Name</b>	Asynchronous Design and Evaluation
<b>Description</b>	The design activity is undertaken in separate locations using the latest requirements and data available at the time of the activity. The design consists of 3D modeling and 2D drawings to describe the product solution, providing the Form, Fit and Function (FFF), which includes the materials and manufacturing processes and also treatments. Discussion and decision making are done remotely using email, WebEx, and/or telephony.
<b>Actors</b>	Designer(s) and Manufacturing Engineer(s)
<b>Challenges</b>	<ul style="list-style-type: none"> <li>• Ensure that the most current data is available and consistent across sites/companies.</li> <li>• Have all actors available at the same time.</li> </ul>
<b>Preconditions/ Prerequisites</b>	<ul style="list-style-type: none"> <li>• Additional principles, including program and leadership support</li> <li>• Need contracts and people in place and data available</li> </ul>

#### **Preconditions/Prerequisites Detail**

Refer to *Use Case 1: Exchange of Product Data* for a description of the preconditions and prerequisites (e.g., data types, exchange frequency, data selection, etc.) common to this use case.

### Use Case 4: Design Review and Approval

As stated earlier, Design Review and Approval ensures that the proposed product solution satisfies the agreed upon requirements, customer expectations, and specifications with due regard to an optimized design that considers safety, performance, cost, reliability, maintenance, and ease of manufacture. Collaboration between OEMs and suppliers provides enough information and data to successfully conduct any specific review. Approval is the formal acceptance by the Technical Authorities/Experts that the engineering solution has met all the requirements.

4. Design Review and Approval (As Is)	
<b>Use Case Name</b>	Design Review and Approval
<b>Description</b>	<p>This process is the formal review and approval of the product solution, using the technical data (e.g., drawings, documents, test plans, etc.) to allow in-depth review of requirements and evaluation of the design solution with validation and sign-off.</p> <p>Data is provided to support delivery of the product, and product delivery is scheduled in support of program milestones.</p> <p><b>Process:</b></p> <p>Define .....schedule meetings with engineering, supplier management, and the supplier to determine what data requirements need to be submitted for review and the appropriate schedules for each.</p> <p>Receive data.....ensure correct information at the correct standard and for the correct requirement– Configuration and Change Management.</p> <p>Conduct review .....review requirements, visualization of the DMU, and markup.</p> <p>Record the review ....capture discussion, results, and scope.</p> <p>Approval workflow..obtain appropriate signatures. If the data is unacceptable, the supplier will make the necessary updates and provide the next revision for review.</p> <p>Publish results.....provide the approved data to downstream users, such as Quality, Manufacturing, and/or authority systems.</p> <p>Engineering reviews and provides their evaluation back to the supplier.</p> <p>Supplier Management acts as the mediator between the supplier and engineering and monitors any changes to the scope.</p> <p>Any changes to the FFF of the deliverable (i.e., part) must be provided for re-evaluation. (Refer to <i>Use Cases 6a and 6b: Managing Configuration and Change Control of the Product Data.</i>)</p>

4. Design Review and Approval (As Is)	
<b>Use Case Name</b>	Design Review and Approval
<b>Actors</b>	Engineering, Supplier Management, Manufacturing, and Quality
<b>Challenges</b>	<ul style="list-style-type: none"> <li>• Export regulations (International Trade Compliance)</li> <li>• IP protection</li> <li>• Data size</li> <li>• Data recipient or sender limitations</li> </ul> <p>(See descriptions below, and also refer to <i>Use Case 2: Work Assignment and Design Delivery</i>.)</p>
<b>Preconditions/ Prerequisites</b>	Data requirements must be determined before contracting with the supplier to finalize what design data is needed and to schedule when each data requirement is due.

**Challenges Detail**

- **Export regulations (International Trade Compliance).** Issues may arise if the user does not know what Export Control Classification Number (ECCN) or United States Munitions List (USML) codes to associate with the data, increasing the chances of mismarking the data design.
- **IP protection.** Refer to *Use Case 1: Exchange of Product Data* challenges for a description.
- **Data size.** If the transmitted files are too large this can cause system time-outs and possible delays in the review process, as well as in downstream processes.
- **Data recipient or sender limitations.** Some companies may not have the bandwidth to submit larger files and have to depend on an alternate route for submitting the data.

**Preconditions/Prerequisites Detail**

Refer to *Use Case 1: Exchange of Product Data* for a description of the preconditions and prerequisites (e.g., data types, exchange frequency, data selection, etc.) common to this use case.

### Use Case 5: Digital Mock-Up

Digital Mock-Up is a 3D representation of a precise, complete assembly and interfacing hardware, including partner/customer parts, tooling, instrumentation, keep out zones, and other modeling that can be visualized using 3D CAD software or integrated into a target PLM system.

<b>5. Digital Mock-Up (As Is)</b>	
<b>Use Case Name</b>	DMU Data Exchange
<b>Description</b>	<p>DMU data exchange provides a file-based, geometrical representation of the product, resources, or production environment (preferably lightweight 3D data) to enable integration into a target PLM system. Usually, this implies conversion activities for 3D and structural data.</p> <p>The frequency of data exchange depends on the need for utilization and ranges from on-off to hourly depending on program requirements or contracts. Recurring updates may contain incremental data only. Typical purposes are the support at any design level in context or technical release and the validation and optimization of prototyping.</p>
<b>Actors</b>	DMU Integrator(s), Design Owner(s) and Author(s)
<b>Challenges</b>	<ul style="list-style-type: none"> <li>• Size of the data</li> <li>• Fail-safe 3D conversion</li> <li>• CAD conversions/neutral data format</li> <li>• Non-standard data exchange</li> <li>• Synchronization process between collaborators</li> <li>• BOM formatting (neutral BOM format)</li> <li>• Cross-organizational boundaries and design team integration</li> </ul> <p>(See descriptions below.)</p>
<b>Preconditions/ Prerequisites</b>	DMU protocol/data exchange agreement

#### Challenges Detail

- **Size of the data.** During New Product Introduction (NPI) programs, the DMU data exchange between the engine manufacturer and the airframer OEM is challenged by a very extensive volume of data. Usually, all the Federal Aviation Regulation Part 25 (FAR25) type design data (i.e., Pylon, Nacelle, EBU) plus FAR33 engine interface geometry (i.e., LRU maintenance) have to be made available in both directions to ensure proper design within the context. There is an estimate of a 30GB average of DMU data volume per year per program being driven by approximately 30,000 native CAD files.
- **Fail-safe 3D conversion.** How 3D data is exchanged needs to be standardized. Currently, one AD PAG member company must deliver many different formats (i.e., everything from CATIA V4 up to CATIA V5R28 to JT). Another works in Siemens' NX. Consequently, all incoming and outgoing data is converted back and forth, introducing the potential for errors and definitely slowing down processes.

- **CAD conversions/neutral data format.** For CAD conversion, quality control should be implemented; that is, calculate GVP before conversion and conduct a re-run after conversion along with a comparison, (e.g., volume, surface areas, center of gravity, etc.). Instead of performing a direct conversion from CAD format A to B, a neutral data format like STEP, JT, etc. could be used to reduce the effort. However, in most cases an OEM wants to receive native CAD formats that fulfill the company's quality and methods, such as naming and numbering, layering, colors, etc. Compared to native CAD, a neutral format already includes some IP protection because, typically, history and design content cannot be retrieved (i.e., only “dump” and dead solids are exchanged, no features).
- **Non-standard data exchange.** Sometimes data that is not part of an engine/airframe is exchanged between engineers at collaborator companies, either because the data is not complete, is 2D and not 3D, or for other reasons. If the data is just emailed or stored and forwarded back and forth, there is nothing in place to revision it or keep it current, leading to potential confusion, misunderstandings, and wasted time and resources.
- **Synchronization process between collaborators.** It is difficult to synchronize what files are with which collaborator. For example, a company has been exchanging data for years, and then one day an engineer references a model that hasn't been used in some time. How does the company know if the *other* company already has that model or if the model needs to be converted and sent? For one AD PAG member company, it is common for each engine/airframer exchange to have a different convoluted synchronization process, usually involving CSV (Comma Separated Variables) files.
- **BOM formatting (neutral BOM format).** A neutral format for the BOM/parts list data exchange is not available. Each PLM vendor has its own “flavor” of PLM XML and STEP 242.
- **Cross-organizational boundaries and design team integration.** These organizational boundaries often inhibit concurrent engineering and data exchange and should be addressed using an integrated product team (IPT) approach to assure comprehensive data exchange. The IPT is a multi-disciplined team assigned with responsibility for a specific program, product, or subsystem that functions to resolve any potential issues and produces an integrated and validated product.

### ***Preconditions/Prerequisites Detail***

Refer to *Use Case 1: Exchange of Product Data* for a description of the preconditions and prerequisites (e.g., data types, exchange frequency, data selection, etc.) common to this use case.

### Use Case 6a: Managing Configuration and Change Control of the Product Data

Controlling and managing changes to the information shared between OEMs and their suppliers are essential to ensure that engineered solutions conform to the design requirements and that the standards/versions of the data being used are understood and reliable. Ensuring the traceability and pedigree of the master design definition is critical. Mechanisms must be in place to ensure the data integrity of the DMU. A lack of trust in the data can be very expensive for a business. Ensuring data pedigree ensures the health of a DMU and the engineering decisions made based on the DMU.

All product data changes by the OEM or supplier must be fully coordinated and authorized. Change agreements between business entities should be in place to support all change activities. Information exchange between OEMs and their suppliers must be managed and controlled precisely and falls into the following two categories:

- Control of the product data inside the TDP (this Use Case 6a)
- Control of the TDP itself (Use Case 6b)

<b>6a. Managing Configuration and Change Control of the Product Data (As Is)</b>																													
<b>Use Case Name</b>	Control of the product data inside the TDP																												
<b>Description</b>	<p>The configuration of the technical data inside any data exchange system is critical to the engineering or manufacturing process and is governed by means of the modification system and the collaboration process/system or tools operated by the OEMs and their suppliers.</p> <p>Typical attributes used to manage the data inside a data exchange package are as follows:</p> <table border="1"> <thead> <tr> <th>Attribute</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>Model Number</td> <td>Part or Assembly 3D model</td> </tr> <tr> <td>Drawing Number</td> <td>Drawing Number</td> </tr> <tr> <td>Sheet Number</td> <td>Sheet number(s) for the drawing to ensure sheet control</td> </tr> <tr> <td>Part Number</td> <td>Unique identifier of a part number</td> </tr> <tr> <td>Revision/Issue/Version</td> <td>Revision/Issue/Version of the part and/or drawing</td> </tr> <tr> <td>Description</td> <td>Description of the part (in English)</td> </tr> <tr> <td>Modification/Change Number</td> <td>Modification or change process control</td> </tr> <tr> <td>Change Description</td> <td>Full description of changes for new version of the part</td> </tr> <tr> <td>Product Effectivity</td> <td>Product for which the part is effective</td> </tr> <tr> <td>Author</td> <td>Designer responsible for the design</td> </tr> <tr> <td>Date</td> <td>Stored date of data/part</td> </tr> <tr> <td>Maturity</td> <td>Design maturity identified</td> </tr> <tr> <td>Export/IP Classification</td> <td>Register regulatory export classification (i.e., 9E991) IP protections</td> </tr> </tbody> </table>	Attribute	Description	Model Number	Part or Assembly 3D model	Drawing Number	Drawing Number	Sheet Number	Sheet number(s) for the drawing to ensure sheet control	Part Number	Unique identifier of a part number	Revision/Issue/Version	Revision/Issue/Version of the part and/or drawing	Description	Description of the part (in English)	Modification/Change Number	Modification or change process control	Change Description	Full description of changes for new version of the part	Product Effectivity	Product for which the part is effective	Author	Designer responsible for the design	Date	Stored date of data/part	Maturity	Design maturity identified	Export/IP Classification	Register regulatory export classification (i.e., 9E991) IP protections
Attribute	Description																												
Model Number	Part or Assembly 3D model																												
Drawing Number	Drawing Number																												
Sheet Number	Sheet number(s) for the drawing to ensure sheet control																												
Part Number	Unique identifier of a part number																												
Revision/Issue/Version	Revision/Issue/Version of the part and/or drawing																												
Description	Description of the part (in English)																												
Modification/Change Number	Modification or change process control																												
Change Description	Full description of changes for new version of the part																												
Product Effectivity	Product for which the part is effective																												
Author	Designer responsible for the design																												
Date	Stored date of data/part																												
Maturity	Design maturity identified																												
Export/IP Classification	Register regulatory export classification (i.e., 9E991) IP protections																												
<b>Actors</b>	Designer(s), Design Owner(s), and Configuration Engineer(s)																												

<b>6a. Managing Configuration and Change Control of the Product Data (As Is)</b>	
<b>Use Case Name</b>	Control of the product data inside the TDP
<b>Challenges</b>	<ul style="list-style-type: none"> <li>• Sending/receiving systems must be aligned and validated to confirm the intent of the attribute exchange is synchronized.</li> <li>• Data must remain in version control for multi-party exchanges and storage.</li> </ul>
<b>Preconditions/Prerequisites</b>	<ul style="list-style-type: none"> <li>• Data exchange agreement</li> <li>• Categorization and classification of data within the system, taking in to account the extraction process. For example, EAR, ITAR data, etc. <a href="https://en.wikipedia.org/wiki/International_Traffic_in_Arms_Regulations">https://en.wikipedia.org/wiki/International_Traffic_in_Arms_Regulations</a>. Another example is IP protection for suppliers' and customers' data.</li> </ul>

***Preconditions/Prerequisites Detail***

Refer to *Use Case 1: Exchange of Product Data* for a description of the preconditions and prerequisites (e.g., data types, exchange frequency, data selection, etc.) common to this use case.

**Use Case 6b: Managing Configuration and Change Control of the Data Package**

As indicated above, information exchange between OEMs and their suppliers must be managed and controlled precisely. This section presents a description and the many challenges of the second category of control—**controlling the TDP**.

<b>6b. Managing Configuration and Change Control of the Data Package (As Is)</b>																			
<b>Use Case Name</b>	Control of the TDP																		
<b>Description</b>	Configuration control of the TDP is critical to ensure that the most recent information is always used by the engineering teams. This control is governed through the collaboration process/system or tools used to maintain the configuration control of the data across OEMs and their suppliers.  Typical attributes used to manage data required for a data exchange package are as follows:																		
	<table border="1"> <thead> <tr> <th>Attribute</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>File Name</td> <td>Package name in the form defined by the naming convention - without split counter and extension</td> </tr> <tr> <td>Time Stamp</td> <td>Package creation date and time</td> </tr> <tr> <td>Operating System</td> <td>Windows, UNIX, etc.</td> </tr> <tr> <td>CAD system</td> <td>Format (including its version) of delivered data files</td> </tr> <tr> <td>Description</td> <td>Description of the data in the data exchange package</td> </tr> <tr> <td>Position Matrix</td> <td>Relative position to the next higher assembly</td> </tr> <tr> <td>Revision indicator</td> <td>Revision letter/number assigned to denote the package revision level</td> </tr> <tr> <td>Revision description</td> <td>Reason for change and description of change (in English)</td> </tr> </tbody> </table>	Attribute	Description	File Name	Package name in the form defined by the naming convention - without split counter and extension	Time Stamp	Package creation date and time	Operating System	Windows, UNIX, etc.	CAD system	Format (including its version) of delivered data files	Description	Description of the data in the data exchange package	Position Matrix	Relative position to the next higher assembly	Revision indicator	Revision letter/number assigned to denote the package revision level	Revision description	Reason for change and description of change (in English)
	Attribute	Description																	
	File Name	Package name in the form defined by the naming convention - without split counter and extension																	
	Time Stamp	Package creation date and time																	
	Operating System	Windows, UNIX, etc.																	
	CAD system	Format (including its version) of delivered data files																	
	Description	Description of the data in the data exchange package																	
	Position Matrix	Relative position to the next higher assembly																	
	Revision indicator	Revision letter/number assigned to denote the package revision level																	
Revision description	Reason for change and description of change (in English)																		
<b>Actors</b>	Designer(s), Design Owner(s) and Configuration Engineer(s)																		
<b>Challenges</b>	Alignment and synchronization of attributes in sending/receiving systems																		
<b>Preconditions/Prerequisites</b>	Data exchange agreement																		

**Preconditions/Prerequisites Detail**

Refer to *Use Case 1: Exchange of Product Data* for a description of the preconditions and prerequisites (e.g., data types, exchange frequency, data selection, etc.) common to this use case.

## Business Consequences

Exchanging CAD and BOM Data between businesses is a complex topic. As discussed above, each business may have its own PLM software, CAD software, and different versions and customizations thereof. Data exchange requires agreements about CAD and BOM type and format to be in place.

Failing to resolve complexities that lead to a slowdown in data exchange of product, program, project, and design data prevents partner companies from effectively communicating on projects. If peer engineers at each company are unable to see the location or the design of parts in place for each other's design, they are unable to perform their job correctly to account for positioning of other parts within the BOM.

The longer that each company's CAD and BOM definitions are not synchronized and drift apart, the lower the effectiveness of communication between engineers at each site. Furthermore, change management of product data and package data is impacted by the same data update drift, allowing engineers to effectively communicate only during time periods directly after data synchronization. Productivity decreases as the amount of time between synchronization increases.

Finally, the business priority and resource requirements to support the items addressed in this paper must be understood and supported by leadership at OEMs and suppliers. Too often these needs are not recognized and appreciated for their criticality to the business and the long-term success of a program. They must be sufficiently funded and supported over the lifetime of a program to avoid "hidden costs" to the business.

## Causal Analysis

The AD PAG project team analyzed the seven use cases presented in this position paper and pinpointed five primary categories of causal factors that contribute to the negative business consequences described above, i.e., the widespread complexities of CAD and BOM data exchange between an OEM and development partners, the potential breakdown of communication on projects, and the likely data update drift (i.e., less frequent CAD and BOM synchronization). The AD PAG team identified Exchange, Conversion Validations, Reconversion Validations, Framework, and Governance as the five root cause categories leading to added complexity, potential confusion, and reduced productivity. The primary stumbling blocks in each category are described below.

### Exchange

- As for data exchange, a package is generated, and the receiver is using this data *asynchronously*. On the sender side, development is ongoing, and this presents a high risk that data within the TDP is very quickly out-of-date.
- Non-standard data that is not part of an engine/airframe is exchanged between collaborator companies, either because the data is in work or is incomplete. If the data is just emailed or stored and exchanged back and forth, nothing is in place to manage revisions or version control, leading to potential confusion and misunderstanding that results in wasted time and resources.
- It is difficult to manage or synchronize what files are with various collaborators. For example, how the company that has been exchanging data for many years knows if the model

is still current or if it needs to be converted and re-sent is a problem. It is common for each engine/airframer exchange to have a different, convoluted synchronization process that is usually negotiated between collaborators.

### **Conversion Validations**

- Single or multiple data conversion is not 100% error-free. Processes to guarantee consistent and complete data are a continuous challenge. Each conversion needs to be validated with appropriate mechanisms, such as geometrical comparison of volume, surface, metadata, and mass properties.
- The conversion process and methods for data exchange need to be standardized. A collaborator may be required to deliver many different formats (i.e., everything from CATIA V4 up to CATIA V5R28).
- Data conversions using neutral ISO standard data formats need to be developed to meet current collaboration and future regulatory requirements.
- Process, methods, and tools need to be deployed to mitigate risk of any data loss independent of the number of data conversions.

### **Reconversion Validations**

- Reconversion requires additional confirmation to assure that no data loss or corruption occurs to validate the integrity of the model.
- It is a best practice to avoid multiple conversions so that the original data remains the “source of the truth.”

### **Framework**

- The primary challenge of the data exchange process is to reach bi-directional agreement about the work content, the information transfer mechanisms, and the process for solving issues and escalations.
- Due to the evolution of CAD/PLM systems, CAD data and metadata size is growing with each tool’s release.
- The volume of product data increases during the lifetime of the program.
- It is critical to ensure that the most up-to-date data is available and consistent across sites/companies. All actors must be available at the same time.
- Suppliers working for multiple OEMs experience many separate and/or interdependent systems installations or customizations, which lead to multiple connectivity instances and consequential challenges. The same data is available at multiple locations and/or converted due to several receivers and/or in different formats. This translates in to high costs for process management, maintenance, and support.
- The data exchange agreement needs to include the alignment of common attributes in supplier systems.

## Governance

- Potential export regulations issues may arise if the user does not know what export classification to associate with the data.
- An IP data protection process must be negotiated and enforced between collaborative parties.

## Go Forward Plan

---

This paper addresses Phase 1 of the AD PAG Global Collaboration project work stream. Research will continue.

Phase 2 will define objectives, a description of the desired state, and To Be use cases. Phase 2 will also specifically address the need to provide a template for a data integration/exchange setup and process and practice protocols consistent with industry standards. The resulting position paper will detail the mechanics of configuring and integrating a supplier in an ideal/optimal/desired state. The intent is that the next position paper release will aid a discussion with the software suppliers and OEMs to deliver the objectives for a collaborative environment.

Phase 3 will define specific recommendations and requirements to help the A&D industry reach its goal of simplified PLM global collaboration.

The team will evaluate and recommend short-term solutions to abate the current barriers using existing 2019 technology, as well as provide an action plan that can be achieved.

## About A&D PLM Action Group

---

The Aerospace & Defense PLM Action Group ([www.ad-pag.com](http://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](http://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.