Minimum Model-Based Definition (MBD) for Type Design Certification

Problem Statement, with Use Cases, Objectives, Desired State, and Go Forward Plan

Release 2.0

May 2020

AEROSPACE & DEFENSE PLM ACTION GROUP
Abstract

Minimum Model-Based Definition (MBD) for Type Design Certification is important to the Aerospace and Defense industry because multiple and ever-changing engineering and manufacturing software tools used to design and produce a product add time and cost by requiring data representation changes to maintain a current definition of the product.

This position paper captures the list of minimum data items required for standard MBD for Type Design Certification. The paper identifies the necessary Part Types and data items within each that are needed to develop, build, and certify the product. The paper first presents use cases As Is today without model-based definition support, including the business impact. The paper then lists To Be (desired state) use cases once minimum MBD requirements are met, including the business benefits. Terms in this paper are defined in a common AD PAG Glossary on the AD PAG web site (www.ad-pag.com). A future third edition of this paper will identify specifics of the minimum required list of data items necessary for minimum MBD support.
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## Revision Record

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<th>Description</th>
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<tr>
<td>1.0</td>
<td>August 2019</td>
<td>Initial Release (Edition 1)</td>
</tr>
<tr>
<td>2.0</td>
<td>May 2020</td>
<td>Second Release (Edition 2) with a revised Abstract and Executive Summary and new content, including Objectives and Desired State</td>
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Minimum MBD for Type Design Certification

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 key business issues 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, one of the key business challenges identified by this group is achieving OEM and supply chain collaboration through bi-directional exchange of technical data packages via digital tools and model-based processes.

In response, a project team of domain experts from the AD PAG member companies has been established to evaluate current data interoperability standards, enabling a Model-Based Definition (MBD) set of concepts, processes, and tools that allow the creation of a semantically (computer interpretable) annotated 3D product definition that is linked to a Bill of Materials (BOM) system. The MBD dataset includes all Engineering Intent requirements (e.g., Process Specifications, Geometric Dimensioning and Tolerancing (GD&T), Product and Manufacturing Information (PMI), and other required information). Combined with Product Lifecycle Management attributes, a parts list, and general notes, this product dataset constitutes an authoritative, single source of master product definition data that does not include or depend upon traditional 2D drawings. The MBD dataset also defines complete requirements for a product in its nominal condition, as well as permissible limits of variation and other acceptance criteria, providing all the data needed to plan, fabricate, and validate an article of product hardware.

The research activity on which this position paper is based was to assess the feasibility of exchanging digital data requirements and systems architecture models instead of documents within a collaborative product development activity. Phase 1, which has been completed with the publication of a position paper in December 2017, identified a gap in the capability of MBD and BOM authoring tools to support data exchange out-of-the-box.

The recommended Phase 2 short-term solution is to evaluate, validate, and employ the use of third-party MBD and BOM interoperability software tools that support data exchange and product interoperability for the life of the product. Edition 1 of this position paper, published in August 2019, includes a problem statement, use cases for the current As Is product interoperability environment, and use case business impacts. The on-going development of this Edition 2 position paper has the AD PAG identifying the desired state with use cases aligned with that To Be environment. In the longer term for Edition 3, the AD PAG minimum set of Part Types and data items within each required for 3D MBD certification support will be detailed. The AD PAG strongly desires to see the data and model interoperability requirements be incorporated with a long-term data retention system.


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 special project, which was initiated in 2017, is Minimum Model-Based Definition (MBD) for Type Design Certification. The scope of the team’s activity has been to agree on the minimum content required in a full 3D MBD definition needed for certification and to agree on a set of recommended standards for representation of that information.

Since the initial agreement in 2016, AD PAG membership has increased from five to ten OEMs, including the addition of Dassault Aviation, GE Aviation, Mitsubishi Regional Jet, Pratt & Whitney Canada, and Safran, and this project team has added subject matter experts (SMEs) from many of them.¹

Drawings Versus Model-Based Definition Content

Drawings have been the descriptive engineering foundation of component design, assembly, and installation since the beginning of the A&D industry. The drawings captured diverse information supported by several pictorial views of the item(s), such as a drawing or part number, dimensions, datums, tolerances, flag notes, general notes, etc. Drafting standards, including the ANSI/ASME Y14² family and the ISO 1101 family, have been supporting the industry’s drawings definition for decades. The drawings were, and in some cases still are, then consumed or repurposed downstream to enable aircraft planning, manufacturing, and servicing.

The rise of 3D CAD (Computer-Aided Design) modelers in the late 1980s and 3D As Master in the early- to mid-1990s ushered in the beginning of MBD in the 1990s. To improve design cycle time and cost, MBD use led to the development of processes and tools that have helped the A&D industry move away from creating 2D drawings and toward 3D models as the data of record.

Industry leaders worked with PLM vendors to define what is known today as Model-Based Definition or Model-Based Enterprise (MBE). This new approach and its continuous innovation have advanced from the basic transfer of all detailed information from 2D drawings to 3D model Geometric Dimension and Tolerances (GD&T) with annotation—known as Product and Manufacturing Information (PMI)—to a recognizable, semantic, fully-dimensionalized 3D model to minimum dimensioning with intelligent features, parameters, and more. These continuous advancements are not only improving the global strategy but are also expanding the gap between industry knowledge, existing standards, and available solutions proposed by PLM software providers.

¹ Bombardier, an AD PAG member at the start of this project, has since withdrawn.
Problem Statement

This section of the position paper first establishes the context within which product development occurs and then identifies, through four current state use cases, the common roadblocks that slow current product development processes that rely on the exchange of model data between stakeholders. Each use case is presented as a user story in table format. Business consequences and the root causes of the problem are noted for each.

Context

As noted earlier, with the advancement of technology and the maturity of CAD tools, the past decades have seen an increase in the transition from 2D drawing-based designs to 3D MBD designs within the A&D community. Today, A&D companies are seeing active CAD data as an asset that is continuously versioning. The available neutral formats, such as ISO STEP AP242, are keeping up at a constant pace, but the scope is also expanding to more and more data types.

A common objective of the AD PAG is to evaluate the minimum digital thread of MBD data elements required to fulfill type design certification requirements set forth by the global regulatory bodies. The team evaluated the certification requirements, the collective part types currently certified by the A&D industry, and the various open data standards such as, but not limited to, ISO 10303-242 (STEP AP242), ISO14306 (JT), and ISO32000/14739 (PRC for 3D PDF) to support data exchange and interoperability requirements for existing MBD design processes.

The AD PAG’s goal is to cover the minimum semantic of the different categories of parts used by the A&D industry. The AD PAG supports the following:

- Communication between the OEM and Engineering suppliers during the design phase of product development.
- Communication to downstream processes between Engineering and Manufacturing with computer-readable semantic data for
  - Preparation of 3D NC machining programming,
– Preparation of 3D NC quality control, and
– Input for simulation of manufacturing processes (specific to each category of part type).

- Communication between Design Engineering and upstream processes, including
  – FEM simulation of structural parts,
  – Electromagnetic Interference (EMI) simulation of electrical wiring harnesses, and
  – Pressure simulation for tubing systems (pumps, etc.).

As a result of this support, the group defined a minimum list of required 3D MBD data items organized by the category of parts. This list was first described in the AD PAG’s published position paper, titled *Minimum Model-Based Definition (MBD) and Bill of Material (BOM) Definition with STEP AP242*, which is available at [www.ad-pag.com](http://www.ad-pag.com) under the link for Position Papers named *Model-Based Definition (MBD) and Bill of Material (BOM) Definition – Position Paper*. The file will download with filename ad-pag-mbd-bom-pp-4.0.pdf. Two additional part types—Deformable and AM - Additive Manufacturing and ALM - Additive Layer Manufacturing—have been added since that paper’s publication. The group is actively researching the following 17 part types.

<table>
<thead>
<tr>
<th>PART TYPE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite - Detail - Core Stiffened Bond</td>
<td></td>
</tr>
<tr>
<td>Composite - Detail - Co-Cured/Co-Bonded</td>
<td></td>
</tr>
<tr>
<td>Casting</td>
<td></td>
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<tr>
<td>Forging</td>
<td></td>
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<tr>
<td>Sheet Metal</td>
<td></td>
</tr>
<tr>
<td>Machined</td>
<td></td>
</tr>
<tr>
<td>Wire Harness</td>
<td></td>
</tr>
<tr>
<td>Tube Assembly - Flexible</td>
<td></td>
</tr>
<tr>
<td>Tube Assembly - Rigid</td>
<td></td>
</tr>
<tr>
<td>Ducting - Metallic - Mechanically Fastened</td>
<td></td>
</tr>
<tr>
<td>Installation</td>
<td></td>
</tr>
<tr>
<td>Standard Part - Mechanical</td>
<td></td>
</tr>
<tr>
<td>Standard Part - Electrical (Connector, Back Shell, etc.)</td>
<td></td>
</tr>
<tr>
<td>Supplied Part - Mechanical Systems (Pump, Actuator, etc.)</td>
<td></td>
</tr>
<tr>
<td>Supplied Part - E/E Systems (Battery, LRU, etc.)</td>
<td></td>
</tr>
<tr>
<td>Deformable</td>
<td></td>
</tr>
<tr>
<td>AM - Additive Manufacturing and ALM - Additive Layer Manufacturing</td>
<td></td>
</tr>
</tbody>
</table>
Use Cases Introduced

The initial edition of the MBD Type Design Certification project identified four current As Is use cases that include the generation of 3D MBD data. Each As Is use case starts on a separate page for easy reference and offers a description of the process, the issues that arise, and the business consequences of their impact.

- 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
Use Case 1: Visual Interpretation and Visual Consumption

Manufacturing has historically relied on visual interpretation of the dimensions, tolerances, and other technical data, such as notes and specifications, to plan and program the fabrication of parts and facilitate inspection, quality, etc. This has been done with 2D drawings for many years. With MBD, the same information (dimensions, tolerances, etc.) is conveyed in 3D space with MBD views. This is done by applying PMI on the 3D geometry.

Visual consumption can be directly from the native CAD system or through a neutral format viewer, such as Adobe with 3D PDF. The ability to visualize the MBD product definition is the most basic and critical use case. Prior to the release of a product definition, many business functions (i.e., manufacturing, quality, assembly) must visualize and approve the design. These functions may not have access to native CAD data; hence, they must use a simplified neutral format with a simple visualization tool (e.g., Adobe 3D PDF).

Production Planners must be able to visualize the dimensions to plan the manufacturing sequences. Numerical Control (NC) and Coordinate Measuring Machine (CMM) Programmers must visualize dimensions and tolerances in conjunction with the 3D geometry to program the NC machine and inspection machine operations, respectively. Any loss of visual data can lead to manufacturing defects.

Regardless of the neutral format used—ISO STEP, ISO JT, or ISO 3D PDF—the visualization tools must quickly and reliably display the 3D model with PMI content.

Difficulties arise immediately whenever the native CAD solution or the neutral format in use does not yet support the MBD display of all necessary data items used in downstream functions.

EPIC: Minimum MBD for Type Design Certification

Feature: Visual Interpretation and Visual Consumption

User Story:

As a: Manufacturing Process Planner
I want to: define the sequence of steps to manufacture the product
So that I can: inform factory floor production staff,
Given: a 3D model-based view of the product.
When: manufacturing process planning is done,
Then: manufacturing planning is complete, and production can start.
Table 2 - Visual Interpretation and Visual Consumption Use Case

<table>
<thead>
<tr>
<th>EPIC</th>
<th>Feature/Sub-Process</th>
<th>CFP</th>
<th>ID</th>
<th>Created by</th>
<th>User Story</th>
</tr>
</thead>
<tbody>
<tr>
<td>As a Manufacturing Process Planner</td>
<td>I want to define the sequence of steps to manufacture the product</td>
<td>So that I can inform factory floor production staff,</td>
<td>Given a 3D model-based view of the product.</td>
<td>When manufacturing process planning is done,</td>
<td>Then manufacturing planning is complete, and production can start.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Tools/Apps</th>
<th>Predecessor</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D data model with PMI Display Viewer</td>
<td>2D drawings</td>
</tr>
</tbody>
</table>

**Business Consequences of Use Case 1**
When downstream NC Programmers or CMM Programmers cannot visualize a needed dimension or other part manufacturing data item, they are left either to interrupt the overall process by requesting clarification from the design organization or to make an assumption. If the programmer’s assumption proves incorrect, time and money are lost in order to correct the problem. In severe cases, the overall product schedule may slip, and the company could miss market opportunities.

**Causal Analysis of Use Case 1**
The predominant cause of missing visual data can often be traced to the lack of capability, either in the CAD solution itself or in a lagging definition within a standard format. In addition, even if the capability is supported, the designer may not realize a particular dimension or tolerance is needed downstream and, as a result, may fail to add it to the 3D MBD view.

One current concern is based on the fact that there are not many different viewers that can accurately display standard data. Development of an application-independent format (or standard) allows suppliers and manufacturers to develop solutions that can significantly reduce their cost of business.
Use Case 2: Feature-Based Machining/Manufacturing

Within MBD, features capture the engineering intent of a 3D model (Product Definition) and serve as significant support for Computer Integrated Manufacturing (CIM). Feature-based design systems typically act as interpretive processors between Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) environment actions. These systems can enable feature-based product definition systems, geometry-based process planning, automatic feature recognition, and design-by-feature systems.

Integrating such technologies is a major concern within current engineering practices and has been a high priority topic for research and development activities. In various engineering and manufacturing domains, the design-by-feature model is a main tenet in the CAD/CAM integration effort. The most preferred system architecture for a feature-based system is a blend of the aforementioned approaches. The approaches used for automatic feature-recognition systems are becoming more mature and are being used in Advanced Manufacturing practices.

The more the A&D industry can utilize Advanced Manufacturing and feature-based capabilities, the more able the industry will be to predict the quality of products coming off the machine tool. This will allow companies to provide to their regulatory agencies better, more accurate data in support of certification and compliance.

Certification of Feature-Based Machining/Manufacturing systems that produce data used for verification and validation, as well as for inspection purposes, must be accredited and approved for use in compliance with regulatory requirements.

**EPIC:** Minimum MBD for Type Design Certification

**Feature:** Feature-Based Machining/Manufacturing

**User Story:**

As a: Manufacturing Employee (Machinist)

I want to: manufacture a machined part from model data

So that I can: meet the OEM requirements/schema,

Given: the data is in an easily readable format that contains the minimum necessary information and requirements to machine/manufacture the part.

When: the part data has been consumed and the requirements have been met,

Then: the OEM job is complete, and the part can be delivered.
Table 3 - Feature-Based Machining/Manufacturing Use Case

<table>
<thead>
<tr>
<th>EPIC</th>
<th>Feature/Sub-Process</th>
<th>CFP</th>
<th>ID</th>
<th>Created by</th>
<th>User Story</th>
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</thead>
<tbody>
<tr>
<td>As a Manufacturing Employee (Machinist)</td>
<td>I want to manufacture a machined part from model data</td>
<td>So that I can meet the OEM requirements/schema,</td>
<td>Given that the data is in an easily readable format that contains the minimum necessary information and requirements to machine/manufacture the part.</td>
<td>When the part data has been consumed and the requirements have been met,</td>
<td>Then the OEM job is complete, and the part can be delivered.</td>
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<table>
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<tr>
<th>Tools/Apps</th>
<th>Predecessor</th>
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<tr>
<td>Intellectual Property (IP)-protected CAD model w/PMI</td>
<td>2D drawing</td>
</tr>
<tr>
<td>Agnostic 3D visualization</td>
<td>STL model</td>
</tr>
<tr>
<td>ISO neutral formats STEP, JT, 3D PDF, etc.</td>
<td>IGES</td>
</tr>
<tr>
<td>LOng Term Archiving and Retrieval methods (LOTAR)</td>
<td>Paper, Velum, Mylar, Linen, Microfiche, etc.</td>
</tr>
</tbody>
</table>

**Business Consequences of Use Case 2**

Today, parts for manufacturing are contracted to suppliers in a variety of formats with varying degrees of requirements. With ever changing software tools, this puts a lot of pressure on suppliers to meet the requirements and keep up with the software.

For programs that had to transition from CATIA V4 to CATIA V5, suppliers were required to read and interpret data from both Version 4 and Version 5 models.

**Causal Analysis of Use Case 2**

The cost of making changes to a company’s infrastructure impacts its ability to compete. Even if the company is well established and has sufficient capital in reserves to pay for the changes, there is still an impact on the schedule and delivery of goods. This may lead to a search for additional suppliers to help meet the schedule, and there is an added cost of review, certification, and contracts associated with potential new suppliers.
Use Case 3: OEM Submission of Technical Data Package to Certification Authority

With the emergence of digital data-based processes, including MBD, requirements were identified that predicate the need for a long-term data retention solution(s) to meet the regulatory and business requirements. Traditional legacy retention and retrieval methods do not support complex digital product definition data.

Prior to MBD, the authorized type design process output was 2D drawings. Certification was performed by providing access to those drawings. In MBD, the design is an annotated 3D model, in which certification can be performed by giving access to the 3D data in a format compatible with the certification authorities. This is a requirement for LOTAR of product and technical data, as defined by the EN/NAS 9300-xxx LOTAR standards.

Those LOTAR standards include the following:

- EN/NAS 9300-001-009 – Basic Fundamentals & Concepts
- EN/NAS 9300-010-030 – Common Process for Data Preparation, Management, Archive and Storage
- EN/NAS 9300-1xx through 7xx – Domain Specific Type Preservation (Mechanical, PMI, Composites etc.):
  - EN/NAS 9300-1xx: LT Archiving and Retrieval of Mechanical Information
  - EN/NAS 9300-2xx: LT Archiving and Retrieval of Product Management Data
  - EN/NAS 9300-3xx: LT Archiving and Retrieval of Advanced Manufacturing Data (Composite, Additive Manufacturing, etc.)
  - EN/NAS 9300-4xx: LT Archiving and Retrieval of Electrical Information
  - EN/NAS 9300-5xx: LT Archiving and Retrieval of Model-Based System Engineering
  - EN/NAS 9300-6xx: LT Archiving and Retrieval of Engineering Analysis and Simulation
  - EN/NAS 9300-7xx: LT Archiving and Retrieval of Electronics Information

Currently with MBD, the certification authorities are given access to the 3D data, according to three types of solutions based on a:

- Lightweight format (3D PDF, ISO 14306 JT, etc.),
- CAD neutral data format (ISO 10303, AP242³), or
- Native CAD model.

This puts the burden of interpreting the native CAD model on to the certification authority that may be certifying multiple OEMs with different CAD systems. Additionally, a native CAD model often contains IP beyond the final design, and the OEM may not wish to expose that IP (e.g., construction methods, constraints, and relationships) to the certification authority. OEMs may want to strip out or mask that data before providing a minimum product definition package to the certification body or restrict access via thin client architectures.

³ AP203 and AP214 have been merged in AP242.
**EPIC:** Minimum MBD for Type Design Certification

**Feature:** OEM Submission of Technical Data Package to Certification Authority

**User Story:**

As an: OEM Supplier

I want to: provide access to a graphic presentation of my product definition

So that I can: show proof of complete product design and definition to the government/regulatory body,

Given: the data is in a readily consumable format containing the minimum necessary information and/or requirements to effectively satisfy the government/regulatory body.

When: the government body is able to access and understand the content of the product definition,

Then: the standard documentation of design is accepted as valid, compliant, and complete.

<table>
<thead>
<tr>
<th>EPIC</th>
<th>Feature/Sub-Process</th>
<th>CFP</th>
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<th>User Story</th>
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</thead>
<tbody>
<tr>
<td><strong>As an OEM Supplier</strong></td>
<td>I want to provide access to a graphic presentation of my product definition</td>
<td>So that I can show proof of complete product design and definition to the government/regulatory body,</td>
<td>Given the data is in a readily consumable format containing the minimum necessary information and/or requirements to effectively satisfy the government/regulatory body.</td>
<td>When the government body is able to access and understand the content of the product definition,</td>
<td>Then the standard documentation of design is accepted as valid, compliant, and complete.</td>
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</tbody>
</table>

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<thead>
<tr>
<th>Tools/Apps</th>
<th>Predecessor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D CAD model (drawing)</td>
<td>Hand Drawings</td>
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<tr>
<td>3D CAD model digital mockups</td>
<td>Physical Mockups</td>
</tr>
<tr>
<td>Enhanced 3D model with PMI</td>
<td></td>
</tr>
<tr>
<td>Agnostic 3D visualization</td>
<td>STL model</td>
</tr>
<tr>
<td>ISO Neutral Formats (STEP, JT, 3D PDF, etc.)</td>
<td>IGES</td>
</tr>
<tr>
<td>LOTAR</td>
<td>Paper, Velum, Mylar, Linen Microfiche, etc.</td>
</tr>
</tbody>
</table>
**Business Consequences of Use Case 3**

Evolving software tools may render certain applications and data formats inaccessible. Inadequate access control and protocols—Intellectual Property Export Control (IPEC) and internal People and Organization (PNO) requirements—create the risk of unauthorized transfer, manipulation, and export of data.

The impact of technology readiness and differences on concurrent collaboration among partners and suppliers may affect the schedule and quality of the product. Failure to keep pace with the evolution of delivery and consumption media creates processes and tools that become isolated and ineligible for further migration. Misinterpretation of product definition may lead to quality issues and loss of design intent.

**Causal Analysis of Use Case 3**

Restricted information flow and misinterpretation of definition, quality issues, and loss of design intent will lead to the potential loss of type data and inability to recreate it, as well as to exposure to data manipulation. This presents a potential for compromised Unauthorized Data Export IP, which may lead to a loss of confidence from the regulatory authorities.
Use Case 4: Statistical Process Control

Statistical Process Control (SPC) is a data-driven methodology for analysis and an improvement methodology for measuring and controlling quality during the manufacturing process. Quality data in the form of product or process measurements is obtained in real-time during manufacturing. This data is then plotted on a graph with pre-determined control limits. Control limits are determined by the capability of the process; whereas, specification limits are determined by the customer. Data that falls within the control limits indicates that everything is operating as expected. Data outside the control limits indicates that the cause is likely the source of process variation, and something within the process should be changed to resolve the issue before defects occur.

**EPIC:** Minimum MBD for Type Design Certification

**Feature:** Statistical Process Control

**User Story:**

*As a:* Quality Assurance Employee

*I want to:* collect and analyze SPC data points from manufactured product data

*So that I can:* meet the OEM design requirements/schema,

*Given:* the data is in an easily readable format that contains the minimum necessary information and requirements to machine/manufacture the part.

*When:* the part data has been consumed and the requirements have been met,

*Then:* the job is complete, and the part can be delivered.

<table>
<thead>
<tr>
<th>Table 5 - Statistical Process Control (SPC) Use Case</th>
</tr>
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<tbody>
<tr>
<td><strong>EPIC</strong></td>
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<tr>
<td>As a Quality Assurance Employee</td>
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<table>
<thead>
<tr>
<th><strong>Tools/Apps</strong></th>
<th><strong>Predecessor</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Mite, SPC sensors</td>
<td>2D drawings, manual measurement</td>
</tr>
</tbody>
</table>
Business Consequences of Use Case 4
- This new process requires new software, integrated with internal software structures and machine tools, along with new processes to capture data. In addition, testing, training, restructuring, and maintenance of these new systems must be in place.
- Implementing an SPC process on machine tools and in quality management policies will impact current operating processes and affect scheduled delivery of the product.

Causal Analysis of Use Case 4
- Restricted information flow
- Difficulty absorbing (i.e., interpreting) information
- Loss of confidence by the regulatory authorities due to poor quality

Objectives
At the start of this MBD project in 2017, the AD PAG members defined and published the team’s mission. The Mission Statement identified that the goal was to develop the common definition for A&D of MBD, including the following:
- The common definition of the content of 3D MBD
- The minimum content to enable certification

The vision of the team is to define the A&D industry minimum standard for 3D MBD and the regulatory Technical Data Package (TDP). The vision also includes providing the team’s requirements to both PLM providers and standards bodies.

The MBD team outlined their task as follows:
- Produce a definition of 3D MBD
- Identify the minimum content of 3D MBD to
  - Satisfy certification requirements
  - Enable manufacturing and support
  - Design integration
- Issue industry requirements to PLM providers and standards bodies
- Identify and test current standards to verify if the standards enable the minimum content
- Test and assess the capability of existing toolsets
- Define the content of the TDP that the OEM proposes to its certification authority
- Provide recommendations to close gaps in standards and toolsets
- Develop guidance and considerations for deployment within the member companies, updating the standards and processes as needed

Desired State (To Be)
This section describes the To Be state of each of the four previously identified use cases. In each, the To Be state has all the data items included in the list of minimum 3D MBD data items necessary for certification supported in the standards and in the PLM solution providers’ tools.
Context
As indicated in the context of the Problem Statement section, the AD PAG’s goal is to cover the minimum semantic of the different categories of parts used by the A&D industry. A minimum list of required 3D MBD data items organized by the category of parts has been defined through AD PAG support of communication between the OEM and Engineering suppliers during the design phase of product development, communication to downstream processes between Engineering and Manufacturing with computer-readable semantic data, and communication between Design Engineering and upstream processes. The group has identified and been actively researching 17 part types, which are listed in Table 1 – List of 17 Actively Researched Part Types by the AD PAG.

Use Case 1: Visual Interpretation and Visual Consumption
In the To Be environment envisioned by the AD PAG, the flow of Use Case 1 is the same, however, now all necessary MBD data is supported by the standards and by the solution providers.

Business Benefits of Use Case 1
The benefit of MBD and MBE contained within the TDP is that the design is an annotated 3D model from which all downstream functions can leverage to complete their work. For the specific downstream function of manufacturing process planning, the manufacturing engineer has access to the 3D product model and all necessary PMI information. The work can proceed according to schedule with quality assured.

Use Case 2: Feature-Based Machining/Manufacturing
In the To Be environment envisioned by the AD PAG, the flow of Use Case 2 is the same, however, now all necessary MBD data is supported by the standards and by the solution providers.

Business Benefits of Use Case 2
The more often the A&D industry can use advanced manufacturing, predictive should-costing, quality control, and feature-based capabilities, the more often the industry will be able to predict the quality of products coming from the machine tool. This enables the association of model part features with manufacturing process steps. It also allows companies to provide to their regulatory agencies more complete and accurate data in support of certification and compliance. Feature-Based Machining/Manufacturing systems that produce data used for verification and validation, as well as for inspection purposes, must be accredited and approved for use in compliance with regulatory requirements.

Use Case 3: OEM Submission of Technical Data Package to Certification Authority
In the To Be environment envisioned by the AD PAG, the flow of Use Case 3 is the same, however, now all necessary MBD data is supported by the standards and by the solution providers.

Business Benefits of Use Case 3
The benefit of MBD contained within the TDP is that the design is an annotated 3D model in which certification can be performed by giving access to the 3D data in a format compatible with the certification authorities’ needs. The government/regulatory body will be able to access and
understand the content of the product definition data throughout the life of the product. This is a requirement for the LOng-Term Archival and Retrieval (LOTAR) of product and technical data, as defined by the EN/NAS 9300-xxx LOTAR standards.

By using MBD within the TDP, the certification authorities can be given access to the 3D data according to three types of solutions based on an:

- Open Data Format: Lightweight format for Visualization (3D PDF, ISO 14306 JT, HTML, ISO 10303-242, etc.)
- Open Data Format: Exact Representation Manufacturing/Inspection (ISO 10303-242, 14306 JT, etc.)

This allows the certification body to certify multiple OEMs with different CAD systems. With the data being CAD agnostic, interpretation will be more accurate as it will not depend on a specific CAD tool to view and interpret the data. The OEMs have the capability to strip out or mask that data before providing a minimum product definition package to the certification body.

**Use Case 4: Statistical Process Control**

In the To Be environment envisioned by the AD PAG, the flow of Use Case 4 is the same, however, now all necessary MBD data is supported by the standards and by the solution providers.

**Business Benefits of Use Case 4**

Statistical process control—in short, the collection and application of statistical methods used to control manufacturing processes—has been around for many years. However, the majority of companies rarely do anything with the data they so painstakingly collect.

With the onset of MBD, it has become critical to use the data collected during the manufacturing process in order to make real-time improvements on the shop floor. This is demonstrated in the Digital Thread/Digital Twin concept where speeds, feeds, and tool changes are made based on the data received in real-time from the machine tools. SPC demonstrates in real-time what is actually happening during the manufacturing process. When equal access to the same data is made available to everyone, more educated decisions can be made during the machining and measurement processes. In addition, manufacturing and quality intelligence through SPC will ensure a more valid and accurate certification process.

**Go Forward Plan**

This paper addresses Editions 1 and 2 of the projected, full position paper. Research will continue. Edition 3 will provide specific recommendations and requirements to help the A&D industry reach its goal of agreement on both:

- The minimum content required in a full 3D MBD definition needed for certification, and
- A set of recommended standards for representation of that information.

Following publication of the full position paper (Editions 1-3), the AD PAG will team with other industry test groups to perform a gap analysis of the AD PAG’s recommended minimum 3D MBD requirements against industry standards definitions and current solution providers’ data exchange tools. For those minimum data items not yet supported in the standards, the AD PAG will petition the appropriate standards bodies to expand the standards based on AD PAG provided priorities.
For those minimum data items supported by the current standards, but not yet supported by the solution provider tools, the AD PAG will petition the solution providers to enhance their tools, based on AD PAG priorities.

The AD PAG will also evaluate and recommend short-term solutions to abate the current barriers to using existing 2019 technology, as well as to provide a clear, step-by-step, future action plan that can be achieved within the A&D industry to enact those recommended short-term solutions.
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.

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