Multiple View Bill of Material (BOM)

Problem Statement and Desired State

Position Paper (AD PAG PP02.1)

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AEROSPACE & DEFENSE PLM ACTION GROUP

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Revision Record

Revision	Date	Description
2.0	Feb 2017	Initial Release
2.1	Dec 2017	Revisions in response to PLM software providers review; reorganization of content; and expansion of Introduction and Desired State sections.

Multiple View Bill of Material

Introduction

Over the past few years, a new conversation has been taking place within the aerospace and defense community arising from a growing recognition that certain persistent pain points—points of friction, complexity, or instability that erode the productivity and quality of product information flow through aircraft and defense systems programs and inflate the cost of systems sustainment—are common across the industry. In March 2016, executives from the Aerospace & Defense PLM Action Group (A&D PAG) member companies—Airbus, Boeing, Embraer, Gulfstream, and Rolls-Royce—met with the intent that informal discussion of PLM-related issues would lead to agreements 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 special project is *Multiple View Bill of Material (Multi-BOM)*. The scope of the team's activity was to compare and contrast single and multi-BOM; and agree on a set of standard solution constructs to address the complexities of multi-BOM while enabling its benefits.

This document presents a set of solution concepts for Multiple View Bill of Material along with the business context within which they were derived. First, the problem, or "pain point", is described, including a characterization of the current negative business impacts. Within this context, business improvement objectives and a set of solution concepts are put forth. This is followed by the team's go forward plan for broadening the contributing industry perspectives, detailing the solution concepts, defining use cases, and deriving requirements. The final section lays out the response requested of the PLM software providers and other relevant entities within the PLM ecosystem.

While the discussion in this document focuses on the Engineering BOM (EBOM) and Manufacturing BOM (MBOM) as the prime multi-BOM example, these same concepts apply to any additional upstream views of the BOM, such as Sales and Configuration BOM, Support and services BOM etc.

The status of this position paper is preliminary, under further refinement by the members. In particular, the project team is evolving the as-is analysis and desired state by ongoing work and will update and reissue this entire position paper in the coming months.

Purpose of this Document

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

In the current stage of contributions to this project, some other leaders in the A&D OEM and the supply chain involved in the A&D industries are also participating in the activities of this group, remembering that, the project team will solicit contributions not only from software providers but also from thought leaders in the A&D supply chain and in non-A&D industries.

Note on Authorship and Endorsement

This document represents the work of a project team staffed with subject matter experts (SMEs) from all A&D PLM Action Group member and invited companies. The content reflects the consensus of member companies with continuing engagements planned to expand the collaboration across the tier-one suppliers. Regardless of their level of contribution, member endorsement indicates strong support and agreement with the main points in the problem description, objectives and solution concepts.

Glossary

One of the first issues that emerged during the conversations involving different A&D PLM Action Group members is the inability to effectively communicate due to the use of different terms for similar concepts (or sometimes even use of same terms for contradictory concepts). In order to overcome this, a glossary of terms has been prepared with strong reliance on publications such as EIA-649, EIA-836 and ATA Spec 2000.The result is a list 75 agreed terms with precise definitions, source (in case it was directly adopted or based on a different publication) and a list of synonyms. Some terms requiring deeper discussion (such as Configuration Control Zone or Occurrence) have been addressed in separate documents and are included as appendices. The glossary will be completed to support effective communication in future subjects and planned updates to the position paper.

Problem Statement

Context

Many A&D companies or aircraft programs are based on a "Design as Built" methodology for the design process to manage a single representation of the Bill of Material controlled by the engineering design department.

As programs mature from product development, manufacturing priorities take center stage and demand adjustments to the Bill of Material (BOM). The constraint of a single BOM forces non-FFF (form / fit / function) changes like work movement in manufacturing or manufacturing process optimization back to the engineering department for implementation.

Other A&D companies or A/C programs are based on a "Design" methodology for the design process to manage a specific representation of the Bill of Material controlled by the engineering design department, with reduced common breakdown with manufacturing activities.

Most of A&D companies have deployed PLM solutions for Design and manufacturing which are not unique. It can be different solutions coming from the same PLM supplier or different suppliers.

Today's PLM tools allow for multiple views of the BOM and Product structures but require reconciliation and complex consumption methods to demonstrate regulatory compliance.

Reconciliation mappings are often duplicated, even when most reconciled elements haven't changed, requiring substantial cost to maintain.

Complex manufacturing operations have multiple use cases (multi-site manufacturing, traveled work, non-conformance, supplier assist, etc.) where reconciliation adds cost.

The complexity surrounding management of multiple BOM views increases with compounding restructuring use cases. Managing alternate part is simple, but when the alternate is used in a manufacturing only super set assembly with an effectivity start in the middle of the effectivity block of the corresponding engineering definition, the complexity is out of today's PLMs management capabilities.

The core of the issue is that no PLM solution offers any out of the box capability or best practice for managing accountability. That complexity is left to the individual companies to figure out and solutions are then added as customizations and reports. Most OEMs simplify the problems by simply restricting some of the use cases, thus forcing undue limitations on different organizations (such as forcing a single As Designed-As Planned structure).

The multi-view BOM concept must facilitate a consistent representation of the same product across its lifecycle, for example, from Design Engineering to Manufacturing Engineering, Procurement, Certification, and post production services.

This concept allows each discipline to have its own references and attributes (common or specific) consistent with upstream or downstream activities to facilitate production.

Current State Comparison between Single and Dual BOM

Definition of BOM Concepts

The single BOM approach is where the Engineering BOM (As-designed) is used directly for manufacturing (As-planned), with corresponding BOM item additions made to support manufacturing and logistic support. This approach is used by Airbus and Embraer.

The dual BOM approach is where the Engineering BOM (As-designed) is separately reorganized for manufacturing (As-planned). This approach is used by Boeing, Rolls Royce, Gulfstream and Bombardier, as shown in Figure 1.

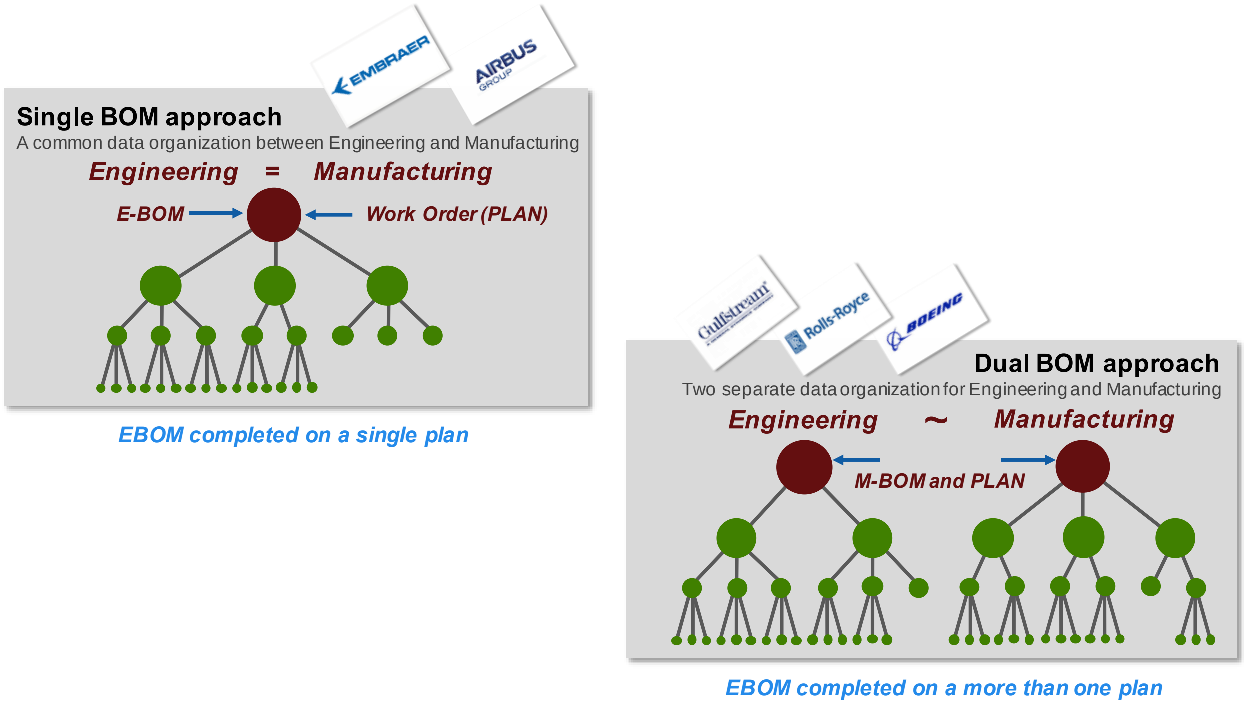

Figure 1—Single and Dual BOM Approach

Single BOM

In a single BOM approach, engineering and manufacturing need to come to a consensus on a common breakdown of the product structure that cannot be deviated from for the life of the product. Airbus and Embraer apply the As-Designed As-Planned Configuration Item (ADAP-CI) concept, which is an agreed invariant element between Manufacturing and Engineering. For example, an ADAP-CI could be "installation of the door" as illustrated in Figure 2.

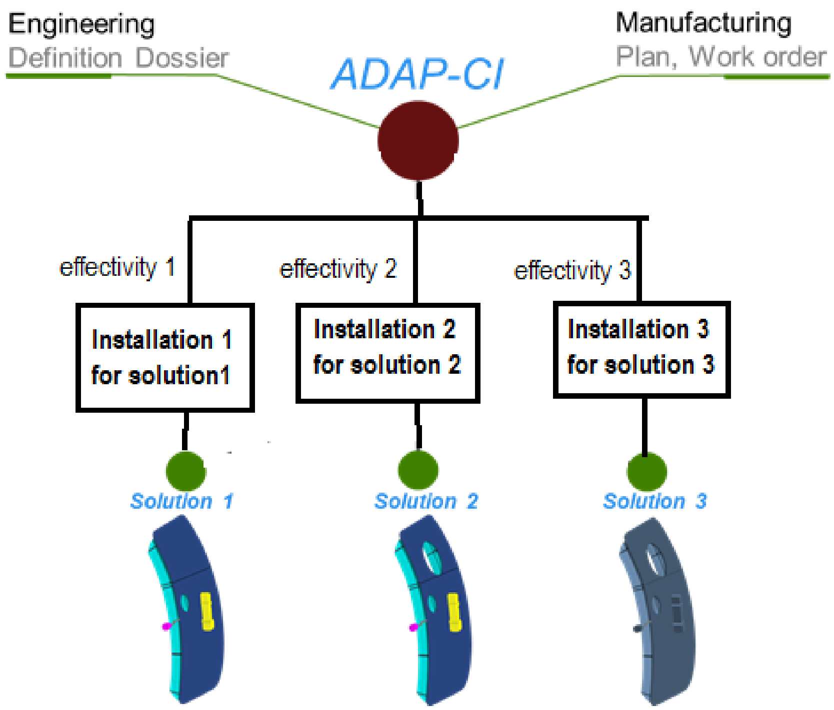

Figure 2—ADAP-CI Example

Dual BOM

In a Dual BOM there are two separate BOM structures that satisfy the needs of the organizations that manage them. While engineering organizes the data mainly to facilitate design reuse, manufacturing focuses more on factory optimization. What is crucial is that at the end every design element and requirement defined in engineering is accounted for in manufacturing. Boeing employs multiple methods to enforce accountability which will be described further in this paper.

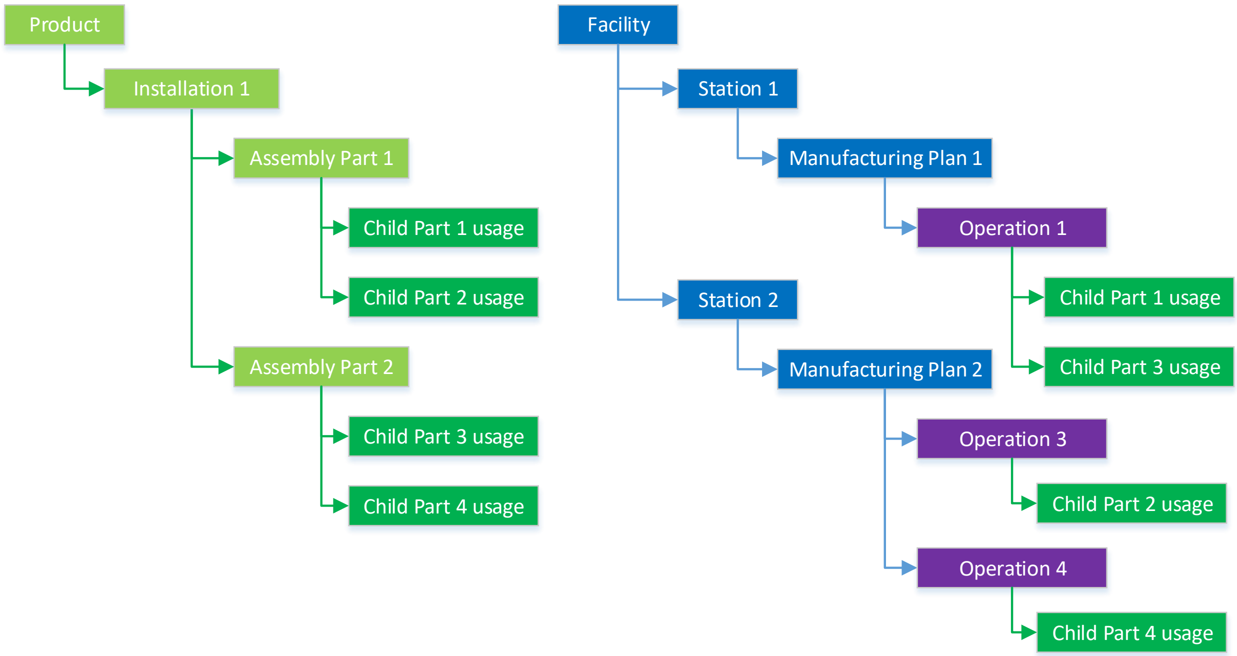

Figure 3—Dual BOM Example

Shared Concept

The main concept shared between Single BOM and Dual BOM is Effectivity management. Whether Single or Dual BOM there are different layers of effectivity that we need to manage. For example, at Boeing, Dassault Aviation, manufacturing effectivity is different from engineering effectivity as shown in Figure 4. The Airbus, Embraer and Bombardier work practice is that MBOM effectivity is derived from EBOM effectivity.

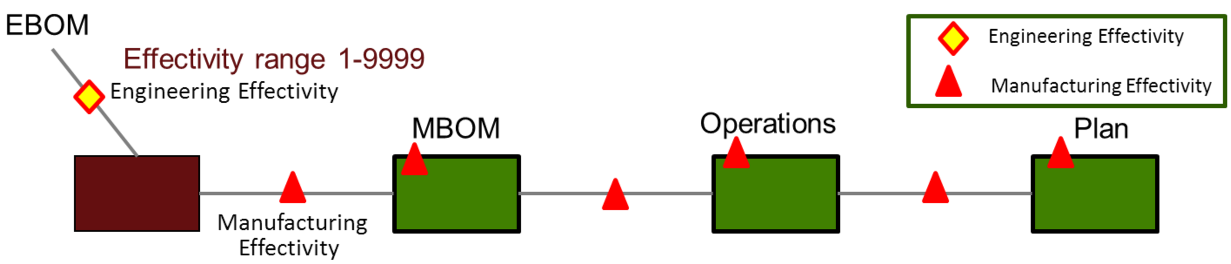

Figure 4—Engineering vs Manufacturing Effectivity

Single BOM Dual BOM Comparison

Single BOM

Advantages

Conformity—As data are in the same organization from end to end, the conformity and traceability of the deliverable product is done easily.

Communication—Easy communication between engineering and manufacturing is an enabler for task scheduling between both organizations, including across the extended enterprise.

The Complexity

Rigidity—Any change in manufacturing organization needs an update in Engineering.

For example, if an equipped pipe has to be installed in another plant to optimize the physical installation, this change (that doesn't change the definition of the aircraft) creates an update of the engineering definition including a CAD/DMU update in Engineering with all the cost linked to re-release and distribution.

Commitment—To reach a common data organization, the route is long and difficult. This process of committing to a Single BOM must be run at each program start or each data reorganization.

Dual BOM

Advantages

Flexibility/Stability—Rapid response for moving parts between work orders to support factory build sequence changes. Isolates the engineering design to define only the "fly away" view without requiring interim assemblies.

Simplicity—Organizations downstream of Engineering can use simple change types to optimize manufacturing without impacting the engineering change process.

The Complexity

Configuration Management and Reconciliation—Each type of BOM restructuring requires **extensive** process and tool development to ensure conformity back to the engineering design. *This complexity is the key business driver for this position paper.*

Integration—Costly integration and PLM tailoring is required to reconcile the Engineering BOM and the Manufacturing BOM

- PLM systems and work processes must be tailored to manage each BOM restructuring type.
- Internal and external supplier systems must be tailored to manage the manufacturing unique processes and data feeds.
- Once created it is very difficult to adapt to new business models.
- Does not integrate with supplier systems.

Opposing Forces

Figure 5 illustrates the opposing forces inherent in a choice between single or dual BOM. This condition leads one to question: Are there any other choices? Is there another model?

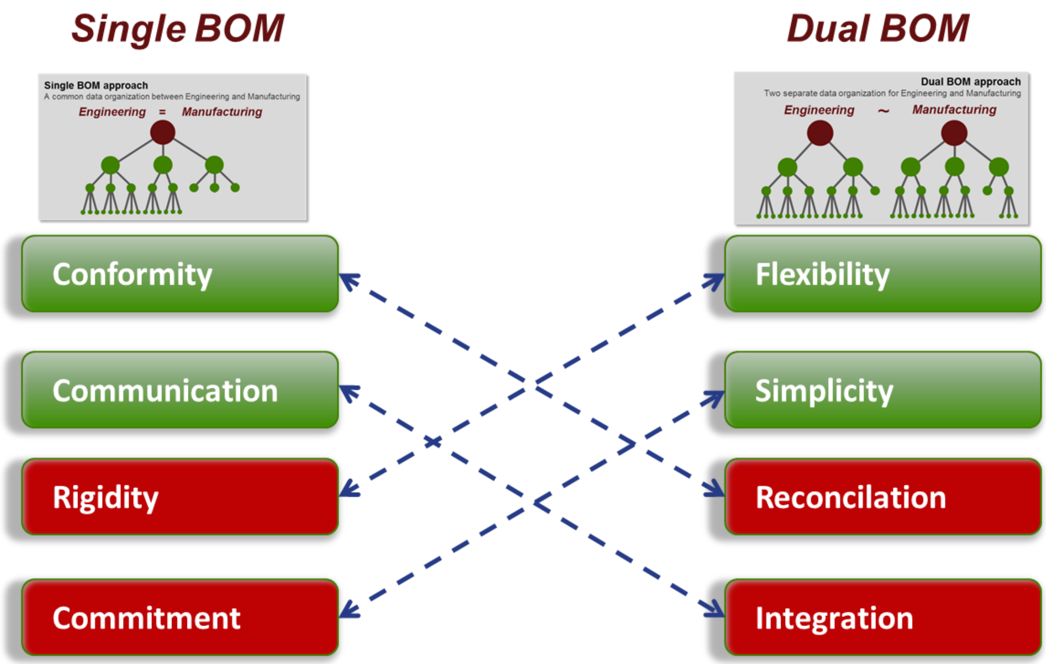

Figure 5—Single vs Dual BOM Comparison

Business Consequences

The cost and complexity of implementing each new generation of PLM creates the need for the aerospace industry to consolidate on common functionality. Instead of decreasing, the costs, time and complexity of deploying PLM platforms is **increasing** with subsequent PLM generations.

PLM providers create flexible capabilities for managing the variation that occurs when the integration occurs between CAD, EBOM and MBOM. Some of this variation is created by "opposing forces" that drive customizations in PLM because there is no industry standard or best practice.

Effectivity

PLM systems allow effectivity on objects and relationships without a common schema to ensure accountability. Lacking an industry best practice in this area, every company must create internal effectivity schemas that are very difficult to change once implemented. There are many different approaches to address this problem. For example:

- Create PLM customizations to keep the EBOM and MBOM reconciled prior to release. (e.g. Boeing Premier models practices)
- Use as COTS, eliminate the MBOM and force the EBOM to manage all manufacturing changes (e.g. Airbus practices)
- Use as COTS with MBOM and use reconciliation reports post release (e.g. ENOVIA/DELMIA Boeing 787 practices)

CAD/EBOM Integration

Each new development in CAD-EBOM design integration impacts the MBOM and downstream solution set.

- Internal tabulation (150% BOM) versus part number control
- Multi Variant Option capability
- Configuration management
- Reconciliation
- Engineering and Manufacturing Process Requirements

Objectives

Overall, the objective is to minimize the pain associated with managing and reusing data in long lifecycle products by having industry standards and best practices and avoiding systematic PLM customizations.

The overall goal of this project is to define a desired future state, business improvement objectives, and a set of derived requirements for PLM solution providers that, if implemented, will give each value stream segment owner **custody of the configuration** that they are responsible for as well as provide a systemic solution between those value stream segments that implements the configuration control requirements of the business.

- People (design engineers, manufacturing engineers, etc.) managing the product.
- PLM solutions managing the artifacts and the relationships from requirements to design to manufacturing to support.

Simply stated, this is the reason **we have PLM** in the first place.

Business improvement metrics defined by the project team are:

1. Capability of a department to have ownership of their product structure.
2. Degree of reconciliation required to maintain segment (engineering, manufacturing, support) structures.
3. Number of A&D use cases addressed by the solution.
4. Level to which effectivity can be managed within the structure.
5. Extent to which engineering change management is accommodated, automatically without manual intervention.

Desired State

The desired state is described here in two parts:

1. A conceptual solution for resolving the opposing forces of advantages and challenges inherent in either single BOM or dual BOM is proposed and described. This is the ultimate target state envisioned by the project team.
2. A systematic discussion of current state issues follows with a proposed remediation for each. Each proposed remediation is highlighted where it occurs in the text. They are then collected as “preliminary requirements” in a later section of the document.

These two parts in combination present a target state and a high-level understanding of some of the barriers that must be removed from the path.

Conceptual Solution: Multi-View Approach

The Multi-View approach, shown in Figure 6 below, is a conceptual solution to the challenges of single/dual BOM implementations today in A&D. In this approach, all product and manufacturing related information is stored in a "data lake," with the appropriate view dynamically generated (or via overnight generation), throughout the product lifecycle. To enforce correctness of views, the "data lake" itself must have mechanisms that **maintain integrity** of the multi view projections. This is where effectivity management in current PLM offerings often falls short.

This "data-lake" shall describe all items considered such as mechanical parts, sheet metal parts, harnesses, fasteners, composite parts, equipment, software...

A Configuration or Engineering View, with appropriate effectivity and level of detail, will be generated by the PLM toolset. Similarly, a Supply Chain View would be generated at point of need for the Supply Chain usage.

This Conceptual Solution shall be considered independent of a single or multiple PLM deployment in a company.

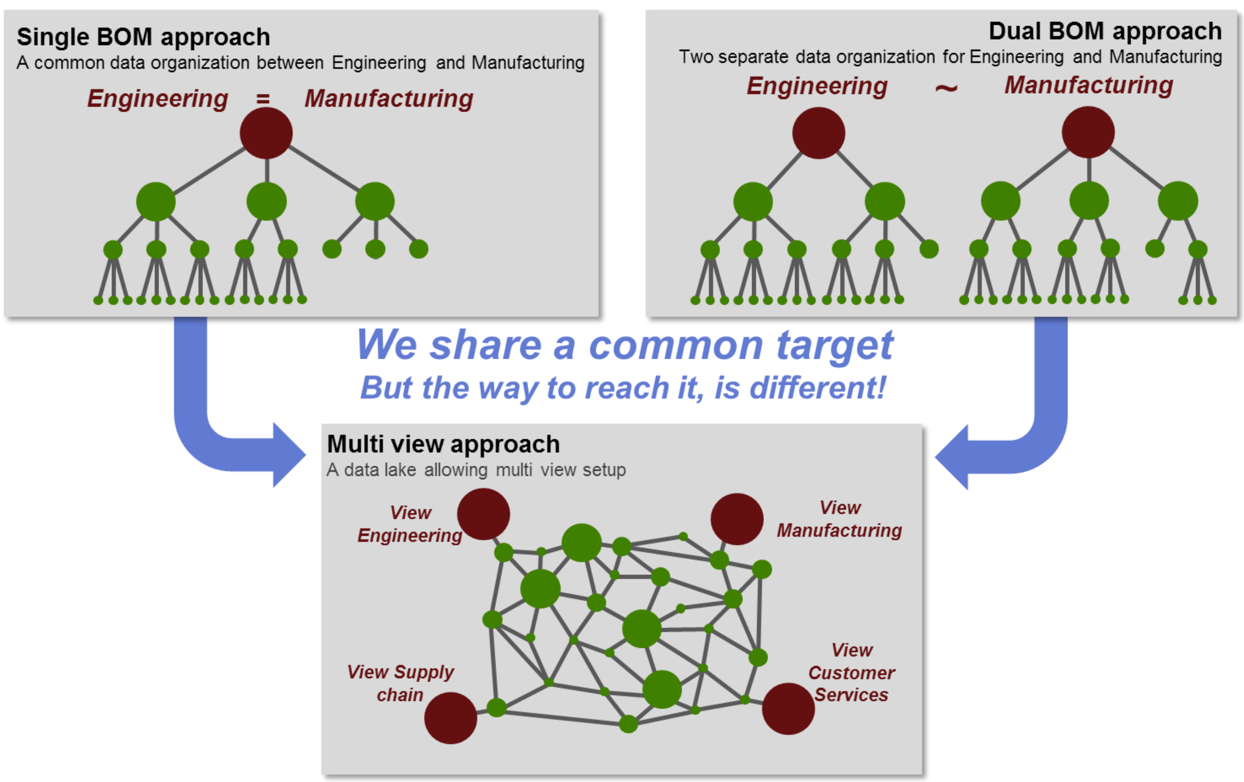

Figure 6—Multi-view Approach

Multi BOM Configuration Description

Multi BOM is a process that allows separate BOM structures to be derived from an authority BOM (i.e. EBOM) with a degree of revision independence. This independence allows changes to be made to downstream BOMs (i.e. MBOMs) by the downstream organizations if those changes do not impact the certified design (Type Design). Typically, such changes (i.e. manufacturing changes) are assembly sequencing changes, kitting and temporary exceptions to the design that are necessary to support cost, quality, and schedule improvements in production.

Multi BOM Accountability

Multi BOM accountability is a process that ensures equivalency between an authority BOM and one or more of its associated downstream BOMs. Accountability is driven by governmental regulations that require manufacturers to have quality management systems in place for the business to achieve production certificates. When manufacturing deviations are defined in the BOM, items such as manufacturing only assemblies, alternate parts, and other manufacturing deviations make the accountability process more complicated. Typically, there are combinations of process and system controls to ensure BOM accountability, and to manage the allowed deviations between an EBOM and any of its derivative downstream BOMs. These deviations are classified as BOM restructuring types.

Architectural Principles

The following architectural principles are necessary to understand the desired PLM system behavior for managing objects, attributes and relationships.

Configuration Control Zones (CCZ)

Please refer to the glossary and Configuration Control Zone appendix for the definition and use cases.

The configuration control zone concept is intended to facilitate the understanding of business rules embedded within the computing technology to manage configured items. This is achieved by establishing system controlled business rules specific to a configuration control zone that must be fulfilled prior to a state change of an object. These business rules are where <u>system enforced accountability rules</u> can be created downstream of the EBOM.

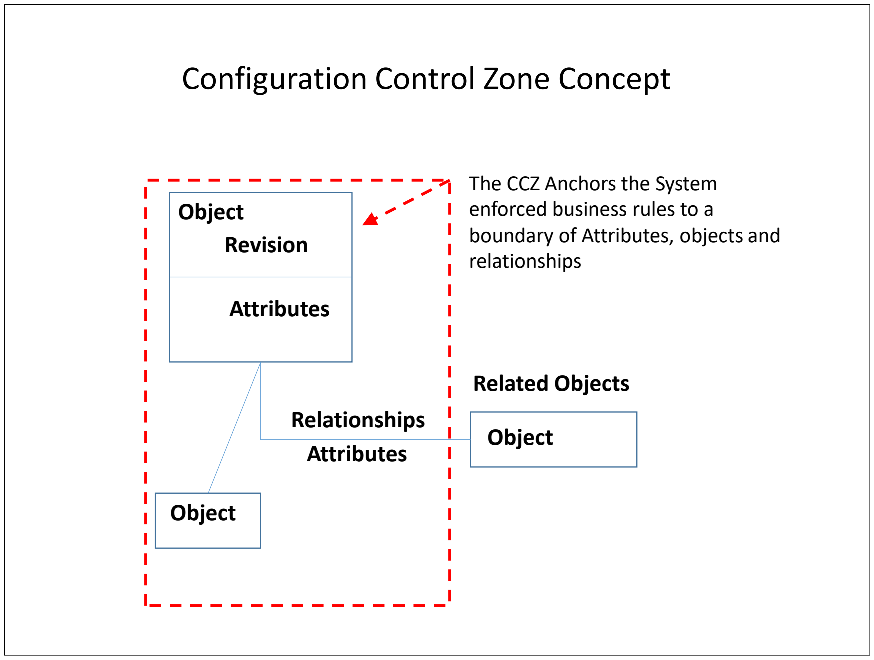

Figure 7—Configuration Control Zone

In Figure 7 above, the CCZ is the boundary within which the business and computing technology define the configuration management rules that are system enforced.

The computing technology that manages configured items also:

- Defines the user selected actions for completeness checks and quality checks prior to a state change or approval.
- Defines the automated system enforced rules:
  - Rules that prevent state changes if not correct
  - Rules that trigger downstream processes and interfaces

Manufacturing Planning

Manufacturing planning is when a manufacturing engineer assigns the parts, engineering specifications and requirements, and notes from an Installation EBOM to one or many manufacturing plans in the production sequence. Each job or manufacturing plan is then performed independently over time within the assembly line. Installations introduce EBOM/MBOM configuration complexity because each part and process becomes part of the end item as they are installed. There is no interim engineering EBOM definition of an installation that can be inspected. This limits the physical factory inspection processes to only inspect the parts within the MBOM of the plan relative to the EBOM. Each plan is inspected incrementally as a manufacturing package of work. This is necessary because of the gaps in time and flow in the build process from the time the first part or process of the installation design is started to when the last part or process of the installation design is completed in the assembly line.

As the inspection activities are done incrementally along the manufacturing stages, the “As Planned” MBOM accountability process is how the A&D industry proves each plan is the correct configuration and that the sum of all the plans’ MBOMs are equal to the EBOM at the end of production. This is the key to allowing incremental inspection of installation designs so when all work instructions are complete, it is recognized that the “As Built” configuration is equivalent to the “As Designed.” When the MBOM projects the EBOM across a large time phased production flow, accountability becomes very difficult if the accountability must be defined from the complete manufactured product backwards into the EBOM.

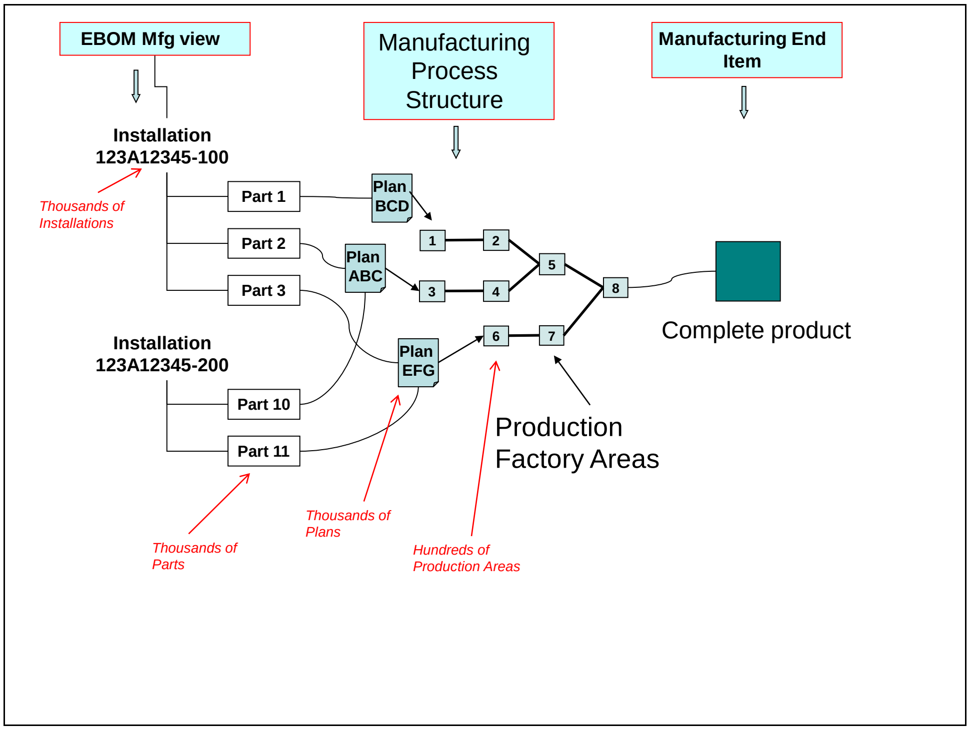

Figure 8—Installations Completed Incrementally Over Time

Accountability Map

An accountability map is a data structure enforcing a set of rules that evaluates the EBOM authority effectivity and ensures that manufacturing effectivity changes are always within the authority effectivity. Accountability rules also cover effectivity, quantity, substitute and optional parts checks and manufacturing only changes to ensure compliance between the authoring Bill of Material (e.g. EBOM) and the downstream one (e.g. MBOM).

Change Action

Change actions fulfill a similar role to accountability maps. Unlike a persistent map that manages the entire structures at all times, change actions only manage changes to authority and downstream structures. Any change action performed on the authority structure produces a set of actions that need to be performed on downstream structures in order to account for upstream changes. Change actions can be directly linked to effectivity that is then applied onto all affected objects.

Change actions specific to downstream structures only can't affect the relations to the authority structure.

BOM Restructuring and Configuration Accountability

BOM restructuring is a computing system capability that controls the allowable BOM deviations with configuration accountability. This capability ensures that when a downstream BOM is approved, the system enforces the equivalency automatically and minimizes the need for additional (manual or process driven) accountability checks. It is viewed as a critical component in the overall quality management system that a PLM system must facilitate because it builds accountability into the process automatically as each downstream BOM is approved, rather than relying on users to run reports or system generated error messages after the BOM has been released.

Corrections are difficult and time consuming and can involve disassembly, rework and/or document effectivity recisions.

BOM Restructuring Types

The following restructuring types require system controlled accountability between BOMs. For a detailed description of each use case, please refer to the appendix document on restructuring use cases. For the following text "parts" shall be considered as any physical items installed on Aircraft such as: mechanical parts, sheet metal parts, harnesses, fasteners, composite parts, equipment, software...

Alternate Parts

An alternate part can be defined such that it can replace the prime part defined in the engineering definition. An alternate can be defined locally (occurrence specific) or globally (all occurrences).

Condition of supply

The condition of supply defines the state of the part as it is expected to be received from the supplier. For example, some holes could be omitted and drilled at installation time.

Split Design Restructure

A split design restructure is the simplest and most common of all restructures. This is when the EBOM is consumed by more than one manufacturing plan (MBOM).

Quantity Split Restructure

A special case of a split design restructure is when the items assigned to different manufacturing plans are sub-quantities of a multiuse part or, in other words, instances of the same reference part. This complicates matters, since many PLM systems' BOMs (including modern ones) are still quantity based with very loose mapping to instance based CAD systems.

In an instance based quantity split, it is easy to split quantities of the same part, since each instance of that part is managed as a separate entity. When an Engineering change replaces or changes a specific instance, there is no ambiguity about which plan is affected.

It is crucial that for each unit number:

- The part counts between the EBOM and the MBOM are equal at release time
- The part counts remain equal at all times after release

The second bullet is just as important as the first. What it basically states is that once a design and its manufacturing consumption are released, the system continues to ensure accountability between the two. PLM systems have struggled to provide out of the box capability to account for all the deviations in the MBOM when the deviation splits a single engineering BOM entry in multiple manufacturing BOM items. Quantity splits are good examples of the issue. This is also where judiciously designed CCZ boundaries can become a huge enabler by building the accountability into the foundation layer instead of reports that rely on a skilled user to interpret, identify and correct.

Manufacturing only assembly

A manufacturing assembly defines a set of parts that is independently authored in the manufacturing definition. Typically this is a condition where the deviation from engineering prevents the use of the engineering part number because the assembly is not "100% per engineering". In order to optimize final assembly of the product, the manufacturing assembly is typically assembled in a back-shop and then consumed into the production line where the exceptions that created the need for the manufacturing only assembly are accounted for and the product can be completed to original engineering assembly definition.

There are several types of manufacturing assemblies:

Subset vs. superset – a subset manufacturing assembly is composed of elements from a single engineering definition, whereas a superset can contain elements originating from separate engineering definitions. The superset becomes particularly complex to manage when the engineering definitions containing the components have different effectivity.

Part number controlled vs. unitized – A part number controlled manufacturing assembly has a defined parts list everywhere it is used whereas a unitized one is filtered and results in a different definition based on its usage (such as AIN of parent product).

Merge

Merging occurs when two or more engineering definitions (EBOM) are consumed in a single manufacturing plan (MBOM).

Make on Assembly (MOA) Restructure

In most cases, parts that are installed are called out in the BOM through direct used-on relationships to the installation. Situations exist when an assembly is built at installation time for various reasons, such as when a better fit can be achieved on installation, or when assembly and fabrication steps can be effectively combined.

Very often, manufacturing assemblies and MOAs are both generically referred to as phantom assemblies. The difference is that manufacturing assemblies only exist in the MBOM and can be consumed as one item, while MOAs are EBOM items whose lower level components are consumed as independent parts and the assembly is "recognized" until all the components of the assembly are installed. In that sense they are actually exact opposites.

This means that multi-BOM accountability needs to be performed at a more granular level. It is no longer sufficient to ensure all parts and assemblies directly used on the installation are accounted for, because a portion of an assembly fabricated at installation time might be missing.

Domain applications (future topics)

A set of key areas has been identified where the accountability is particularly troublesome. Each of those areas is being explored as a subproject with the goal of establishing a set of requirements and providing a vision statement. Those subprojects are in development and the PLM Action Group will update the position paper as it comes to consensus.

Assembly Level Engineering Requirements

The first special topic being tackled by the group is the management of assembly level engineering requirements, including torque specifications, fastener stack ups, sealants, shims, functional tolerance and annotation, etc. Today, those are typically managed in monolithic containers such as text files or CAD documents. This inhibits the ability to individually manage the engineering requirements downstream and limits their visibility to end users.

This topic also includes management of standard parts, including fasteners as well as alternate parts and how those are captured in different BOM views.

The following list describes a high level vision of what the management of assembly level requirements should look like.

- The PLM toolset enables computer-sensible processes to validate and measure the fulfillment of engineering requirements by manufacturing processes
    - Ability to have a single source of truth totally shared between engineering and manufacturing for requirement definition and downstream solutions.
        - Systematical tracing of requirements to consumption in downstream structures.
        - Integrated library to connect requirement definition (engineering) and downstream implementation (manufacturing). Validation and verification. Consistent implementation of solution.
    - Accountability of consumption of all the tasks in the right order downstream.
        - Adequate timing taken into account on manufacturing to "consume" the requirement (ex. can't inspect a hole if already sealed)
    - Trace evolution of the steps from requirement definition to implementation.
    - System provides instructions to properly execute engineering requirements - automated plan creation/intelligence in data to create plans.
        - System has to provide instructions to properly execute the requirements.
        - Ability to drive engineering requirements with contextual help.
        - Turbo Tax-like wizard for requirement consumption/ work instruction creation. Give us the architecture so we can fill in the right information. Also assists with part accountability.
- Internet of Things is used to perform accountability between physical and virtual, quality assurance and automation
- Machine learning is applied in order adapt delivery of kits (i.e. correct grip length of rivets)

Capturing evolving configuration for single Aircraft Identification Number

PLM systems typically manage the engineering configuration of a product through unit effectivity so that it is possible to resolve the latest fly-away configuration of any given physical unit. The management of interim configuration before the latest fly-away configuration is considered difficult. What is lacking is the management of the evolution of that unit and its interim configurations. This is necessary in many cases such as:

- pre-delivery changes (concessions, out of sequence activities, late changes)
- Post-delivery (SBOM) (repairs, service bulletins)
- non-OEM changes
- Changes to a flight test unit aircraft that may not occur during the flight test campaign
- Identification of interim configuration such as “green aircraft” (e.g. for Business jets)

Data exchange/sharing with suppliers and partners

The vast array of PLM and CAD systems as well as the large amount of customization on top, force most suppliers and partners to have dedicated specialists for each OEM with which they do business. This represents a very large cost that is wasteful and ultimately transferred to the OEMs.

Additionally, the data feed is overwhelming for suppliers as it often includes the latest version of the entire structure as opposed to the net change.

Business Benefits

PLM systems need enhanced capabilities to facilitate the management of BOM data across the digital thread as the data transforms across each organization and process with 100% completeness and accountability. At the physical part level, where details and assemblies are part number controlled, the industry already uses best practices of “Fit/Form/Function” rules that are well understood. However, large end items that are fabricated in a production line as a “Aircraft Identification Number” or “Production Line Number” have extensive home grown processes and system customizations unique to each company. Our objective is to work together to create an industry accepted foundation of multi BOM capabilities for major end item type production. This would allow all companies to use multi BOM best practices and standards that are 100% understood, accepted, and supported by PLM. Each company must be able to select various levels of PLM Multi BOM capability to fit their internal business requirements using the tailoring settings within the PLM. The objective is zero PLM customization (tailoring only) to support multi BOM.

Go Forward Plan

At the conclusion of this first project phase, the project team and A&D PAG member sponsors assessed performance and made substantial adjustments to the project approach. The next phase approach is structured to be broader and more inclusive. All members have committed to participate in a workshop environment and, as the phase 2 project progresses; participation will be opened to software providers and to A&D suppliers. This revised approach was tested in 2017, and will be continued through the remaining phases.

Three Step Approach

The project team has defined a three-step approach to reach their target and make their solution concept real, as outlined in Figure 9.

1. **Basics—**Perform first level analysis across A&D PAG members on BOM usage and product structures. This will be done as a detailed survey sent to all members, concurrent with this Position Paper’s publication (already accomplished for the original topics).
2. **Translate basics into proposed PLM solutions**—Harmonize the survey results, looking for commonality among work methods, business processes and PLM implementations.
3. **Facilitate A&D collaboration—**Share the common Multi-View BOM position paper and use cases with PLM providers for common knowledge and implementation.

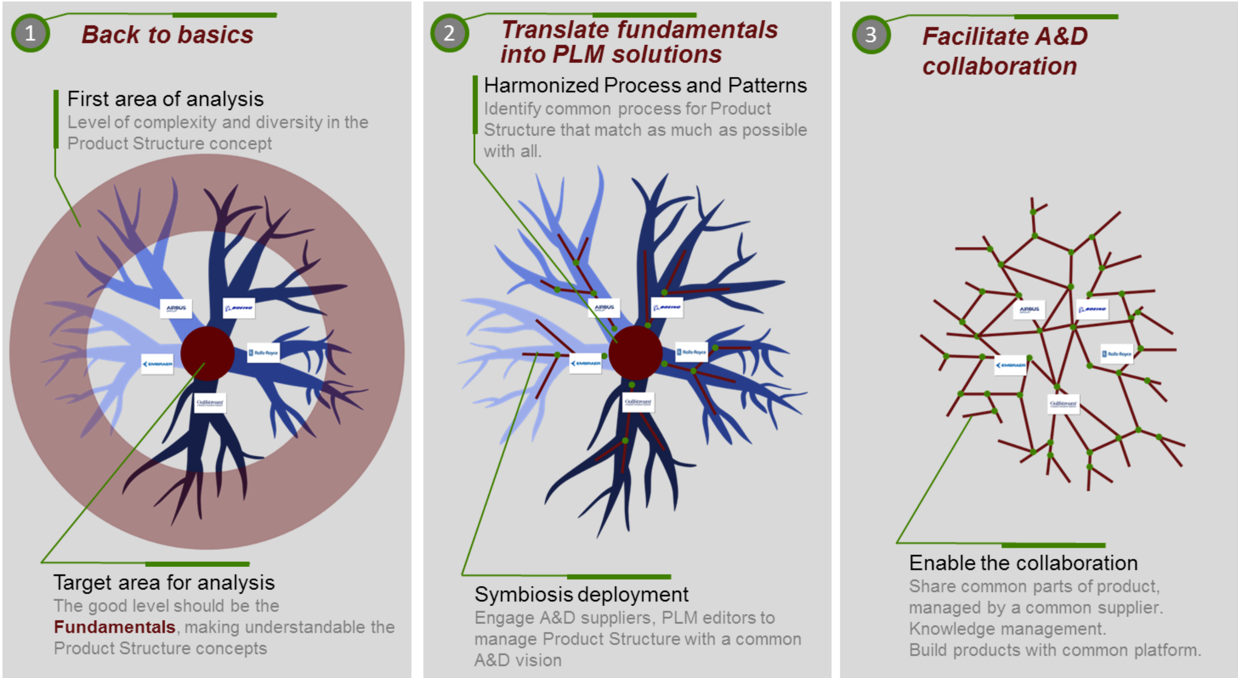

Figure 9—Proposed Multi-BOM Solution Roadmap

Use Cases for Requirements and Validation

Use case definition is an essential part of developing and validating any Multi-View BOM implementation. The use cases are included in an appendix to this positions paper.

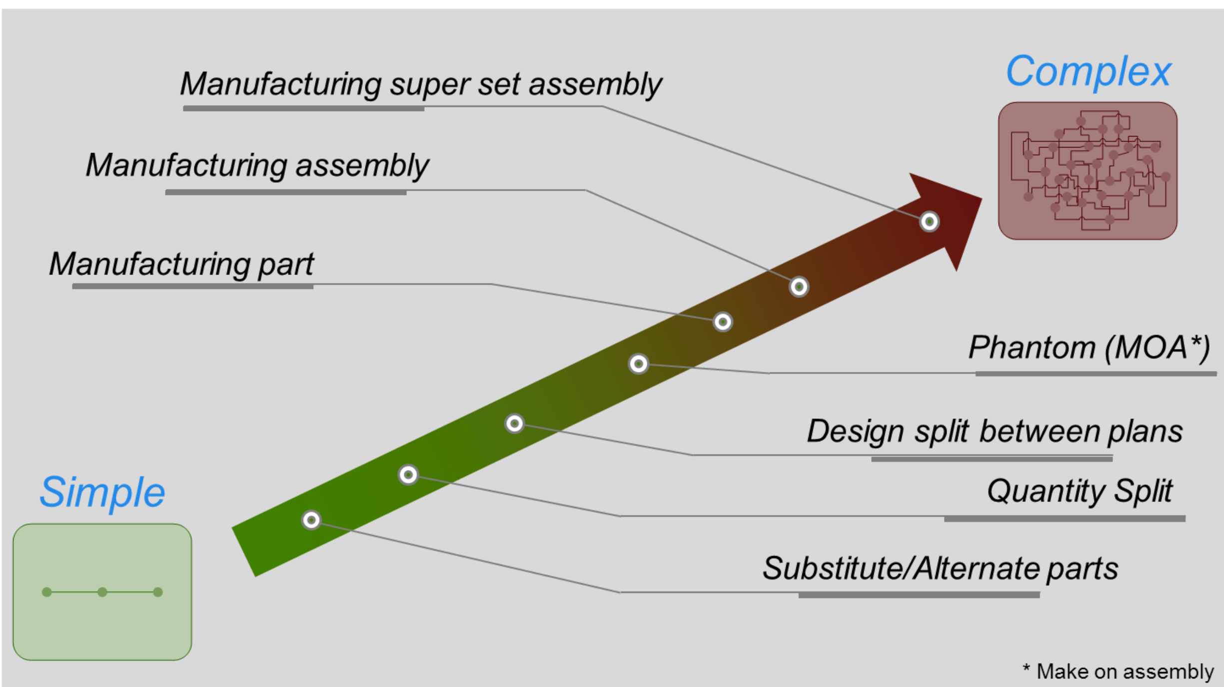

Figure 10—Use Case Hierarchy

Way of Working

A team of experts (3 or 4 people per member company) has been assembled. A series of physical workshops is being conducted with all experts.

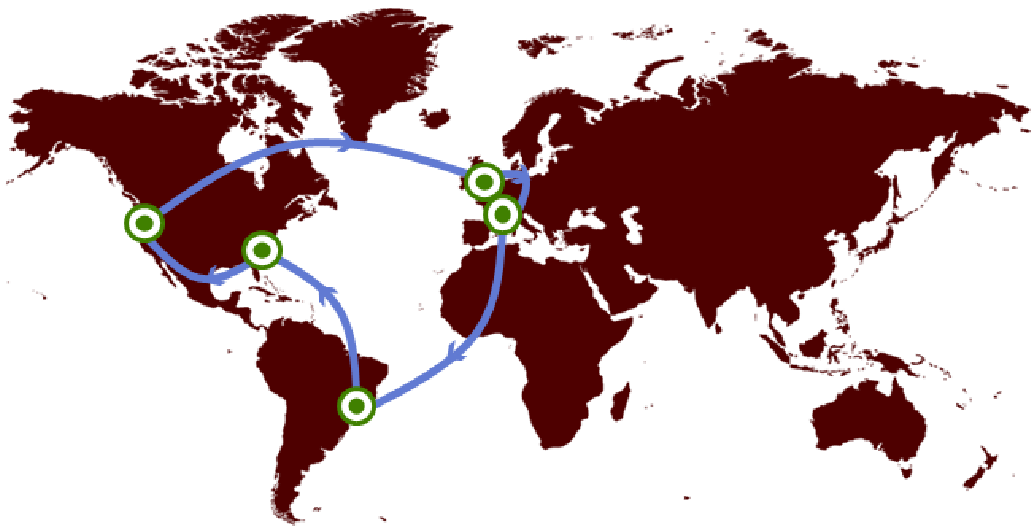

Figure 11—A&D PAG Member Locations

The first workshop, which took place in March 2017 focused on developing common language across members' diversity of practices and a deep dive into the Product Structure concept. The second workshop took place in September 2017 and focused on reaching a consensus on the glossary and the restructuring use cases. Subsequent workshops will focus on key topics surrounding multi-view BOM management, such as described in the *Domain applications (future topics)* section.

Requested Response

The A&D PLM Action Group wrote this paper to demonstrate our understanding of the issues and to communicate our intent. We ask that you, as representative of a PLM software provider to the A&D industry, respond in support of our effort with the following actions:

- Provide your comments and suggestions for improvement of the Problem Statement, Objectives, and Desired State as documented in this paper.
- State whether you accept each of the Architectural Principles and Preliminary Requirements documented in this paper. For those that you do not accept, provide an explanation for your position, and if appropriate suggest an alternative.
- Describe in what fashion and to what degree your current products and future product roadmaps comply with the Architectural Principles and Preliminary Requirements documented in this paper.
- Recognizing that the content of this paper is directional and incomplete, state whether you will support and participate in further refinement of the requirements.

About A&D PLM Action Group

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

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

CIMdata administers 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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