Multi-View Bills of Material:

PLM Action Group

Development & Status

Kenneth Swope
PLM Action Group
Multi-View BOM Team

RROI# 17-00290-BCA
Kenny leads the Enterprise Business Architecture team for an internal initiative called 2nd Century Enterprise Systems. In addition, Kenny is responsible for the BCA Business Architecture organization. In this capacity, Kenny is responsible for the technical configuration of the business strategies, value streams, process mapping and business data definition with integration across both business units and functions of Boeing. As a combined organization of governance and administration, Business Management provides a single source for determining the health of the BCA Process & Tool System, the configuration of that system and the integrated change targeted for the system. Finally, Kenny is active in international standards as Chair Elect of ISO Technical Committee 184/SC 4 “Industrial Data” and a Liaison Officer to ISO TC 171 “Document Management Applications.”

Over 23 years with the Boeing Company, Kenny has served in Processes, Tools & Affordability, Program Planning and Control, Program Management, Manufacturing Research and Assembly Operations.

Kenny holds a Master’s degree in Engineering Management from Washington State University, a Bachelor of Science degree in Mechanical Engineering from the University of Missouri-Rolla and a Bachelor of Arts degree in Physics from Central Missouri State University. Kenny is certified in Configuration Management II and Theory of Constraints. Kenny is active in his local community, serving as Program Manager for Snohomish County Washington 4-H Technology, a mentor to Team 4309 FIRST Robotics and coach to two First Lego League teams in Snohomish County.
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- A&D Primes & Engine Manufacturers

- Advocate for industry best practices

- Promote common requirements to standards bodies
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Background

• Seven Aerospace companies working with CIMdata on PLM multi-BOM methodologies
  • Common Objectives
  • Aligned Requirements
  • Shared Use Cases

• First workshop held in Toulouse France, March 2017
  • First time the industry has shared openly the PLM functions used internally for managing Multi-BOM configuration

• Additional companies added this summer
  • Bombardier, Spirit, Latecoere, GKN (Fokker), FACC, Triumph, SAAB.

• Bi-weekly collaboration progressing the work to a set of white papers communicating use cases and requirements to solution providers.
Move the aspiration to an higher level

3 steps to reach the target

1. **Back to basics**
   - First area of analysis
     - Level of complexity and diversity in the Product Structure concept
   - Target area for analysis
     - The good level should be the **Fundamentals**, making understandable the Product Structure concepts

2. **Extract Backbone**
   - Harmonized Process and Patterns
     - Identify common process for Product Structure that matching as much as possible with all.
   - Symbiosis deployment
     - Engage A&D suppliers, PLM editors to manage Product Structure with a common A&D vision

3. **Become A&D community**
   - Enable the collaboration
     - Share common parts of product, managed by a common supplier.
     - Knowledge management.
     - Build products with common platform.
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Task List from Workshop 1

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- **Assembly requirements:** *Product Manufacturing Information must be reusable downstream and semantic.*

- **Best practices to treat Multi BOM: eBOM, mBOM, sBOM:** *capability to manage instance and assembly information between eBOM and mBOM after split.*

- **How change/action is propagated in Multi BOM:** *system must ensure effectivity management when changes occur to eBOM and mBOM (split, merge...).*

- **Downstream BOM restructuring for substitutes:** *PLM should be able to substitute parts applicable to specific product locations and cross products.*

- **Engineering Process Requirements:** *identify engineering requirements account to secure distribution and reconciliation of engineering process in mBOM.*

- **Glossary:** *create a glossary for common terms used in the industry.*
Best practices to treat Multi BOM: eBOM, mBOM, sBOM: capability to manage instance and assembly information between eBOM and mBOM after split.

• Walk through three examples at the Assembly/Installation level
  • Establish an engineering baseline
  • Engineering change to the baseline
  • Manufacturing change post engineering change

• Material is proposal at this point; comments will feed into our next workshop.
The EBOM definition uses a top “parent” part number as a single configuration.

Only one level of effectivity expressed as a unit effectivity “from and through” at the parent level. No lower level effectivity on children components.

Detail or assembly components in file structure are under the parent.

Relationships with attributes that define usage, spatial location, etc.
The EBOM baseline has six components, and there are two separate usages of the -2.

Note that in the following examples, only the -2 and -3 will be used for MBOM restructuring examples. The same rules would apply to all parts and in some examples, consumption into the bill of process is shown for all parts.
The MBOM has two key areas that need clarification to know where the accountability is taking place:

1. Parts ordered from suppliers and internal fabrication sites.
2. Parts consumed into an airplane level process structure that accounts for the completeness and accountability of each airplane.

**As Designed (EBOM)**

-30 10-9999
-2 -3
-4
-2
-5
-6

**Major assembly production (Final Assembly)**

-30 Derived from
Mfg Assy
-2-001
-3

**Procurement and part fabrication**

**This side of the MBOM defines the configuration being procured**

**Final assy work order**

**This side of the MBOM defines the configuration being installed**
These examples will demonstrate how the EBOM is restructured into an MBOM with the configuration control zone (CCZ). The accountability map concept in these examples uses a separate CCZ from the engineering definition and the manufacturing plan revision. A key point is the need for **Three separate CCZs**.

1. **EBOM CCZ** is the typical engineering assembly CCZ where the parent part number owns the usage of the children. Conventional PLM functionality and configuration management practices used today address this.

2. **Accountability Map CCZ** owns the relationships and attributes that map between the EBOM and the MBOM. This CCZ provides computer sensible enforcement of the data and relationships between BOM structures and demonstrates how to enable persistent BOM accountability.

3. **Mfg Plan CCZ** defines the plan to operation instruction relationship that are needed for production work orders. In these examples, the plan CCZ does not own the parts consumption. Part assignment to plan is performed in the Accountability Map CCZ.
The EBOM CCZ is not different from what we understand today with PLM.

The Accountability Map CCZ is significantly different by owning the BOM restructuring and part assignment to a plan header. In addition to BOM accountability, this concept facilitates part to plan assignment for early part ordering. Detailed operation instruction authored in the plan CCZ may occur at a later date.

The Mfg Plan CCZ owns the detailed operation instructions. Because parts are already assigned to the plan header, the mfg plan CCZ can only assign parts to operations that exist on the plan header. This allows the Plan to re-sequence operations, make work instruction changes, create mfg graphics etc without impacting accountability map.
Accountability becomes more complex as change is introduced. The following scenarios demonstrate the complexity using a change timeline against the BOM structures.

1. Establish the baseline configuration for both EBOM and MBOM.
2. Demonstrate accountability with EBOM change evolution.
3. Demonstrate accountability with MBOM unique change evolution.
Scenario 1 will define the MBOM baseline with two manufacturing deviations to the EBOM for procured parts and the consumption of the manufacturing parts into the final assembly process structure.

**Step 1: Deviation 1 for procurement**
- I need to replace this -2 with a manufacturing part -2-001

**Step 2, Deviation 2 for procurement**
- And create a manufacturing part number controlled assy with these parts

**Step 3: For Final Assy**
- and consume the manufacturing assembly into the final assembly planning

**Step 4: Consume the MBOM items into the final assy plans**
- Final assy work order
- Major assy item
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Accountability change scenario: Step 1

1. User selects the -2 and selects “create manufacturing part replacement”.
2. The PLM system creates a dialog for the user to define the new manufacturing part number along with the required information to define the manufacturing part with allowed deviations.
   - E.g. “New -2-001 same as -2 except all pilot holes omitted for use at location XYZ. Reference Mfg change request….”
3. PLM system creates the -2-001 and also creates a “restructured” relationship between the -2 and new -2-001.

Baseline Scenario: create the MBOM for procured parts.
Baseline Scenario: create the MBOM for procured parts.

1. User selects -2-001 and the -3 and selects “create new manufacturing assembly”.
2. The PLM system creates a dialog for the user to define the new manufacturing assembly.
   - e.g. “New mfg assy -901 same creates a sub assembly with -2-001 and -3 using installation requirements from -30. Reference Mfg change request....”
3. PLM system creates the -901 and also creates a “restructured” relationship between the -901, -2-001 and -3.
4. Note that the -901 also requires data from the -30 for the geometry and engineering requirements necessary to assemble the -2 and -3 together. The “derived from relationship” allows manufacturing assembly -901 to be linked to -30 for this reason. This relationship may also be used to keep effectivity synchronized between -30 and -901.

As Planned (MBOM)

- Derived from Mfg -901
- Restructured -2-001
- Restructured -3
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Accountability change scenario: Step 3

Step 3

1. In order to complete the MBOM accountability, -901 assembly must be consumed into a work order for installation.
2. If the user manually runs an accountability check prior to approval the system will ensure -901 is consumed for the same effectivity ranges as engineering.
3. As part of the release process, the accountability map is used to validate system enforced accountability processes and all consumption is completed.
The CCZ of the accountability map controls the restructuring relationships and the consumption of the EBOM into Installation plan headers. Not to the actual operations.

Although these parts are not in the change scenarios, the accountability map ensure all parts in the EBOM have consumption to an installation level plan for the full effectivity of the EBOM.

The CCZ of the Installation Plan controls the operation instructions and Parts to operations. Typically this requires “relationship to relationship” capability in PLM. The accountability map owns the part to plan header, so any changes requiring movement of part between plans requires an accountability map revision and installation plan revision.
So far, only a baseline is established between EBOM and MBOM.

The new -31 does not impact the manufacturing deviations in the old -30. PLM shall eliminate the need to recreate (re-plan) the same deviations in the new -31 AND update the accountability map to account for the design evolution. (REQUIREMENT)
Engineering change impacts the baseline EBOM

Change Scenario, -30 is replaced by new -31

There are several ways PLM could carry forward relationships for design changes. In this example, a Stable ID is used to identify the -2 and -3 as the same “usage” (part at location, etc) in both the -30 and -31.
The MBOM restructuring configuration between -30 and -31 is common. PLM shall notify and allow the user to automatically re-apply the original restructures in the -30 to the new -31. In this example, new relationships must be created by PLM to update the accountability map to validate the configuration and effectivity of the MBOM related to both the -30 and -31.

Rule check:
10-49 OK!
50-9999 OK!

After the user accepts the “re-apply MBOM restructures” the system automatically updates the accountability map.
A manufacturing only change starts at unit 70. -2-002 manufacturing part replaces -2-001 for a deviation (e.g. pilot holes). A new -902 mfg assy is also needed to replace the -901 to control the incorporation point of the manufacturing change.

Rule check is still OK after the change because the accountability map is updated to account for the MBOM configuration effectivity common to both the -30 and -31:

- -30 consumption check 10-49
  - -2 (replacement -2-201) and -3 used on -901 for full range
- -31 consumption check 50-9999
  - -2 (replacement -2-001) and -3 used on -901 50-69
  - -2 (replacement -2-002) and -3 used on -902 70-9999

PLM keeps the accountability map current based upon the system enforced method provided to the user for restructuring.
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Additional Restructure Types

• The Previous examples represented:
  • Replacement restructure (-2 replaced by -2-001)
  • Manufacturing Assembly -901 (Airbus -3001)

• Additional Scenarios to Evaluate
  • Phantom Assemblies (Or Make On Assembly)
  • Alternate Parts
  • Manufacturing Super Set Assemblies
    (many EBOMs to one manufacturing assembly)
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Next Steps

- 2nd workshop planned in Seattle, WA on September 25th - 28th
- Potential additional workshops in 2018.
Thank You
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## Team Roster

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<thead>
<tr>
<th>Members</th>
<th>Company</th>
<th>Email Address</th>
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<tbody>
<tr>
<td>Benoit Plante</td>
<td>Airbus</td>
<td><a href="mailto:benoit.plante@airbus.com">benoit.plante@airbus.com</a></td>
</tr>
<tr>
<td>Javier Reinés Palao</td>
<td>Airbus</td>
<td><a href="mailto:francisco.reines@airbus.com">francisco.reines@airbus.com</a></td>
</tr>
<tr>
<td>Pepe Chulian</td>
<td>Airbus</td>
<td><a href="mailto:pepe.chulian@airbus.com">pepe.chulian@airbus.com</a></td>
</tr>
<tr>
<td>Kenny Swope</td>
<td>Boeing</td>
<td><a href="mailto:kenneth.a.swope@boeing.com">kenneth.a.swope@boeing.com</a></td>
</tr>
<tr>
<td>Bruce Hiebert (informal team leader)</td>
<td>Boeing</td>
<td><a href="mailto:bruce.hiebert@boeing.com">bruce.hiebert@boeing.com</a></td>
</tr>
<tr>
<td>Alek Przbylo</td>
<td>Boeing</td>
<td><a href="mailto:aleksander.przybylo2@boeing.com">aleksander.przybylo2@boeing.com</a></td>
</tr>
<tr>
<td>Ian Gilkerson</td>
<td>Boeing</td>
<td><a href="mailto:ian.t.gilkerson@boeing.com">ian.t.gilkerson@boeing.com</a></td>
</tr>
<tr>
<td>Pierre Barbeau</td>
<td>Bombadier</td>
<td><a href="mailto:pierre.barbeau@aero.bombardier.com">pierre.barbeau@aero.bombardier.com</a></td>
</tr>
<tr>
<td>Jean Francois Cugy</td>
<td>DS Aviation</td>
<td>Jean-Francois.Cugy@dassault-aviati</td>
</tr>
<tr>
<td>Fernando Lana</td>
<td>Embraer</td>
<td><a href="mailto:fernando.lana@embraer.com.br">fernando.lana@embraer.com.br</a></td>
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<tr>
<td>Flavio Pinho</td>
<td>Embraer</td>
<td><a href="mailto:fpinho@embraer.com.br">fpinho@embraer.com.br</a></td>
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<td>Almir Alves</td>
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<td><a href="mailto:almir.alves@embraer.com.br">almir.alves@embraer.com.br</a></td>
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<td>GE Aviation</td>
<td><a href="mailto:bob.fletcher@ge.com">bob.fletcher@ge.com</a></td>
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<td>GE Aviation</td>
<td><a href="mailto:michael.d.carlton@ge.com">michael.d.carlton@ge.com</a></td>
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<td>Gulfstream</td>
<td><a href="mailto:dan.ganser@gulfstream.com">dan.ganser@gulfstream.com</a></td>
</tr>
<tr>
<td>Greg Weaver</td>
<td>Gulfstream</td>
<td><a href="mailto:Greg.Weaver@gulfstream.com">Greg.Weaver@gulfstream.com</a></td>
</tr>
<tr>
<td>Mike Clarke</td>
<td>Rolls-Royce</td>
<td><a href="mailto:Mike.Clarke@rolls-royce.com">Mike.Clarke@rolls-royce.com</a></td>
</tr>
<tr>
<td>Chris Gregory</td>
<td>CIMdata</td>
<td><a href="mailto:c.gregory@cimdata.com">c.gregory@cimdata.com</a></td>
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Aerospace & Defense PLM Action Group

Founded in February 2014

Administered by:

CIMdata | Global Leaders in PLM Consulting
www.CIMdata.com
Aerospace & Defense PLM Action Group

Mission

An association of aerospace & 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
- 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 member-prioritized industry and technology topics
Aerospace & Defense PLM Action Group

Membership eligibility

As per the charter, eligible for membership are:

- Commercial aircraft OEMs
- Defense OEMs – Aeronautics and space sectors only
- Aircraft engine providers

Other Tier 1 commercial aircraft suppliers aren’t included in the current scope.

PLM solution providers cannot be members, but may participate as guest attendees at specific Group meetings in the future.
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Cooperative action

Topics and issues

Priorities set annually

Categories of action

- Research
- Direction statements
- Requirements
- Policy

Guiding principle regarding standards

A&D PLM Action Group will participate in standards groups and promote standards adoption in support of common industry PLM practices, but will not manage standardization process or content
Aerospace & Defense PLM Action Group

Value proposition

Each member company contributes funding.

CIMdata administers Group operations within its PLM Community Program, coordinates research, and manages the progression of policy formulation.

Funding the Group’s activity rather than relying on the effort of volunteers or vendor contributed resources indicates the seriousness of members’ intent and their desire for timely performance to plan.

Enhanced and Accelerated Outcomes

**Internal Improvement:** Specific actions members can take within their companies and supply chains

**Engagement with Solution Providers:** Managed 4-step progression from intention to policy

**Engagement with Standards Bodies and Projects:** Advocacy for development and promotion of adoption of targeted standards
As Designed (EBOM)

-3 10-9999
-2
-3
-4
-2
-5
-6

The deviation

I need consume all the components of the -3 Assy instead of the Assy

Installation planning scenario, not fabrication planning!

Note: The accountability map would not need to account for components of the -3 Assy in the normal condition where the -3 Assy is actually issued to manufacturing as an Assy. The Phantom condition creates new rules for the accountability map because the lower level components of the -3 need the same level of reconciliation as the -3.
I need consume all the components of the -3 Assy instead of the assy.

I need to identify the -3 as phantom and assign the components to two separates plans.
Step 2: PLM accountability map update triggered by the restructure.

The accountability map adds the components of the -3 into the configuration control zone (CCZ) of the map. The ensures that all the components of the -3 are accounted for in the MBOM as if they were children of -30 and not just the -3.
Step 3: User consumes the components of -3 into installation level (Final Assy) plans

The accountability map ensures all components of the -3 are consumed into plans with effectivity checks and verification same as if they were components of the -30.
Note: the accountability map does rules do not need to account for alternate parts in the BOM. Only the Prime parts in the BOM are included in the accountability map rule set. To make this switch between prime and alternate, the MBOM needs to flip between prime / alternate relationships.
The deviation

I need to make a Mfg assy to pre-assemble parts together per a factory request to reduce assembly time in final assy.

The accountability map shows the -2, -3 and -4 being restructured into the Manufacturing Assembly. Accountability must now be traced to the consumption and effectivity of the Assembly. By having the Manufacturing Assembly inside the same CCZ as the design it was derived from, EBOM and MBOM accountability can be synchronized.
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Additional Restructure Types: Manufacturing Superset Assemblies

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The accountability map facilitates the manufacturing unique changes by keeping the start and stop of the mfg configurations in a single CCZ. This requires PLM to manage the manufacturing effectivity starts and stops in context with the EBOM effectivity.