Multi-View Bills of Material:

PLM Action Group

Development & Status

Kenneth Swope
PLM Action Group
Multi-View BOM Team

RROI# 17-00290-BCA

Biography

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.

PLM Action Group

- **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.**

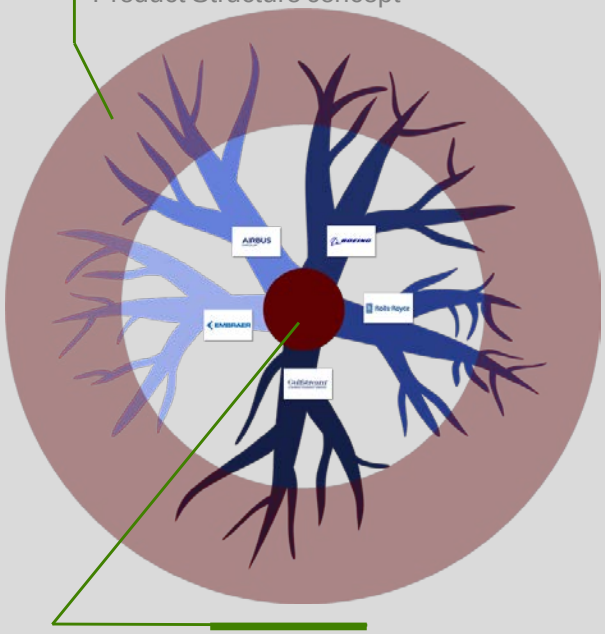
Benoit Plante	Airbus
Javier Reinés Palao	Airbus
Pepe Chulian	Airbus
Kenny Swope	Boeing
Bruce Hiebert (informal team leader)	Boeing
Alek Przbylo	Boeing
Ian Gilkerson	Boeing
Pierre Barbeau	Bombadier
Jean Francois Cugy	DS Aviation
Fernando Lana	Embraer
Flavio Pinho	Embraer
Almir Alves	Embraer
Bob Fletcher	GE Aviation
Mike Carlton	Ge Aviation
Cecil New	GE Aviation
Dan Ganser	Gulfstream
Greg Weaver	Gulfstream
Mike Clarke	Rolls-Royce
Chris Gregory	CIMdata

Move the aspiration to an higher level

3 steps to reach the target

1 Back to basics

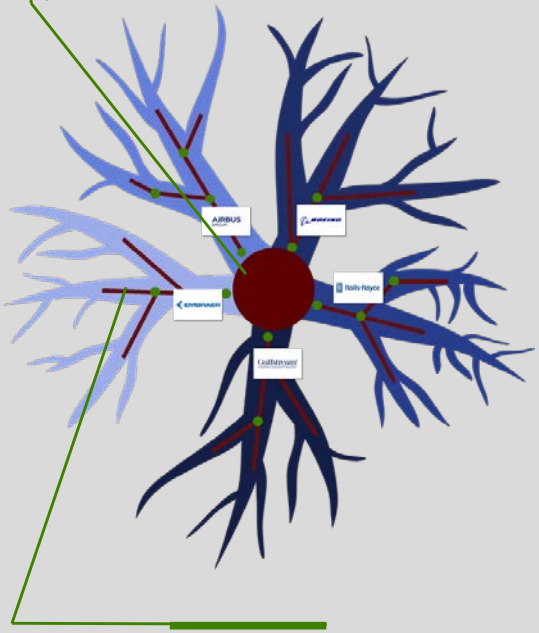
First area of analysis
Level of complexity and diversity in the Product Structure concept



Target area for analysis
The good level should be the **Fundamentals**, making understandable the Product Structure concepts

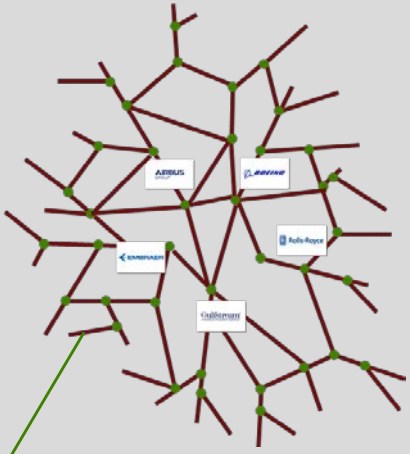
2 Extract Backbone

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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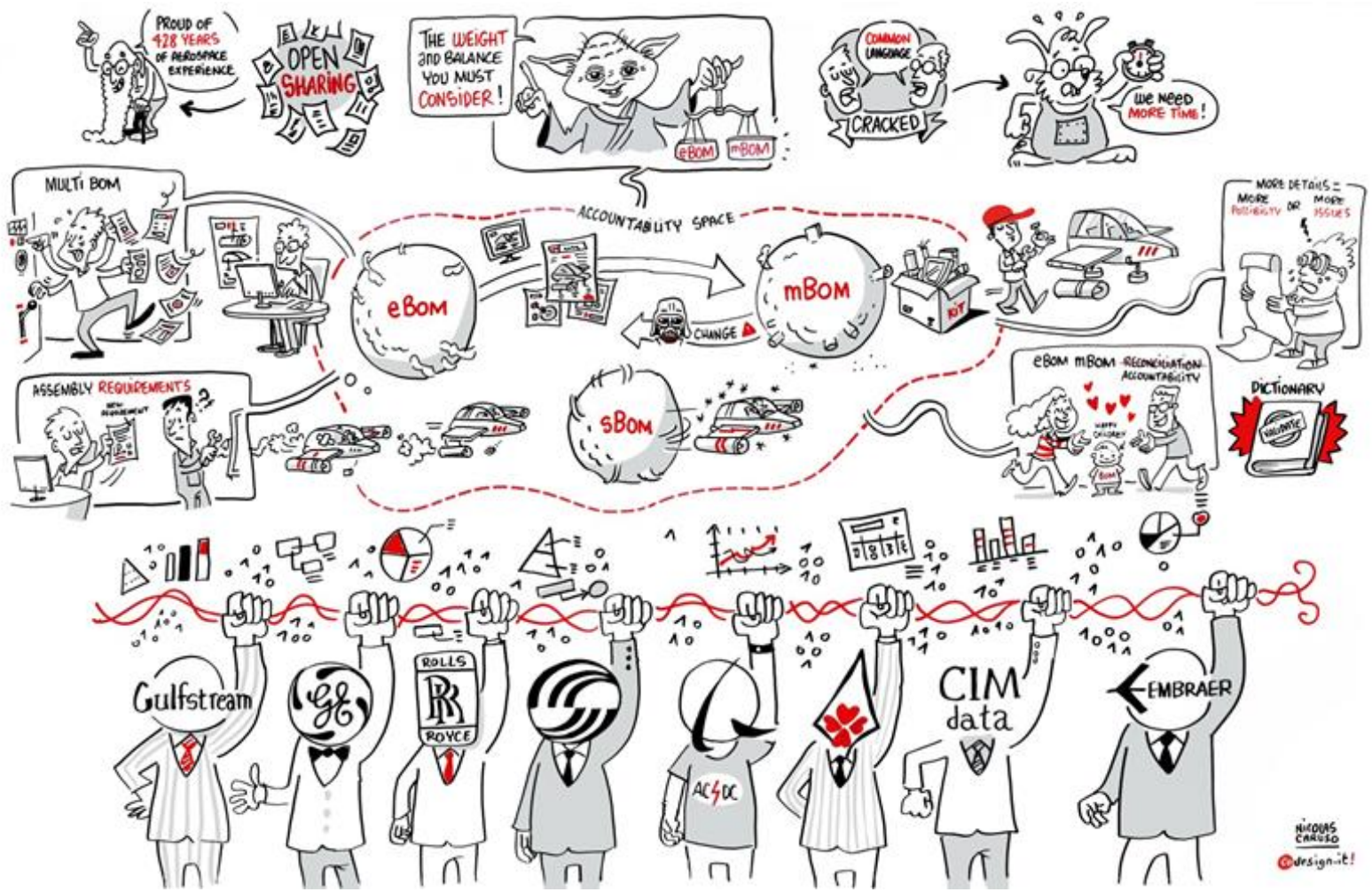
Collaboration Approach

Global Product Data Interoperability Summit | **2017**



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Task List from Workshop 1

- **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.*

In work

- **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.*

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Example Scenarios

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

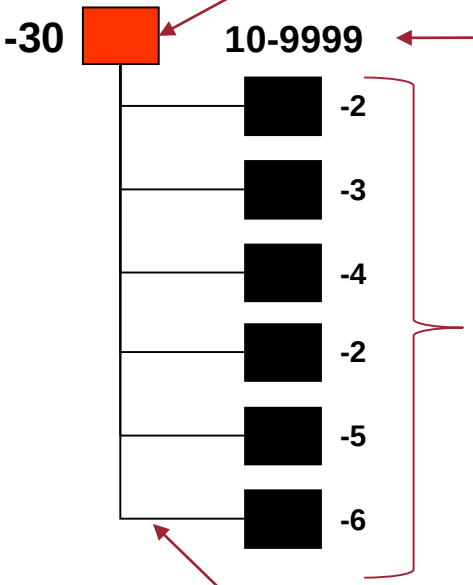
- **Walk through three examples at the Assembly/Installation level**
  - **Establish an engineering baseline**
  - **Engineering change to the baseline**
  - **Manufacturing change post engineering change**

- **Material is proposal at this point; comments will feed into our next workshop.**

How to understand the following use case scenarios

EBOM assumptions / rules for scenario

As Designed (EBOM)



The EBOM definition uses a top “parent” part number as a single configuration.

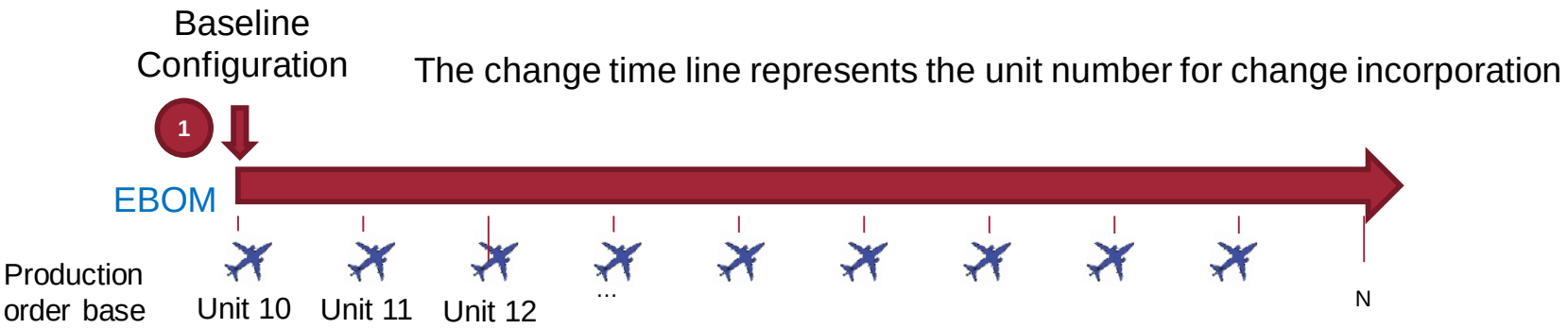
Only one level of effectivity expressed as a unit effectivity “from and through” at the parent level. No lower level effectivity on children components.

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

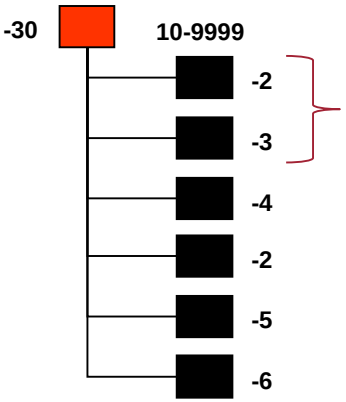
Relationships with attributes that define usage, spatial location, etc.

How to understand the following use case scenarios

EBOM assumptions / rules for scenario



As Designed (EBOM)



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.

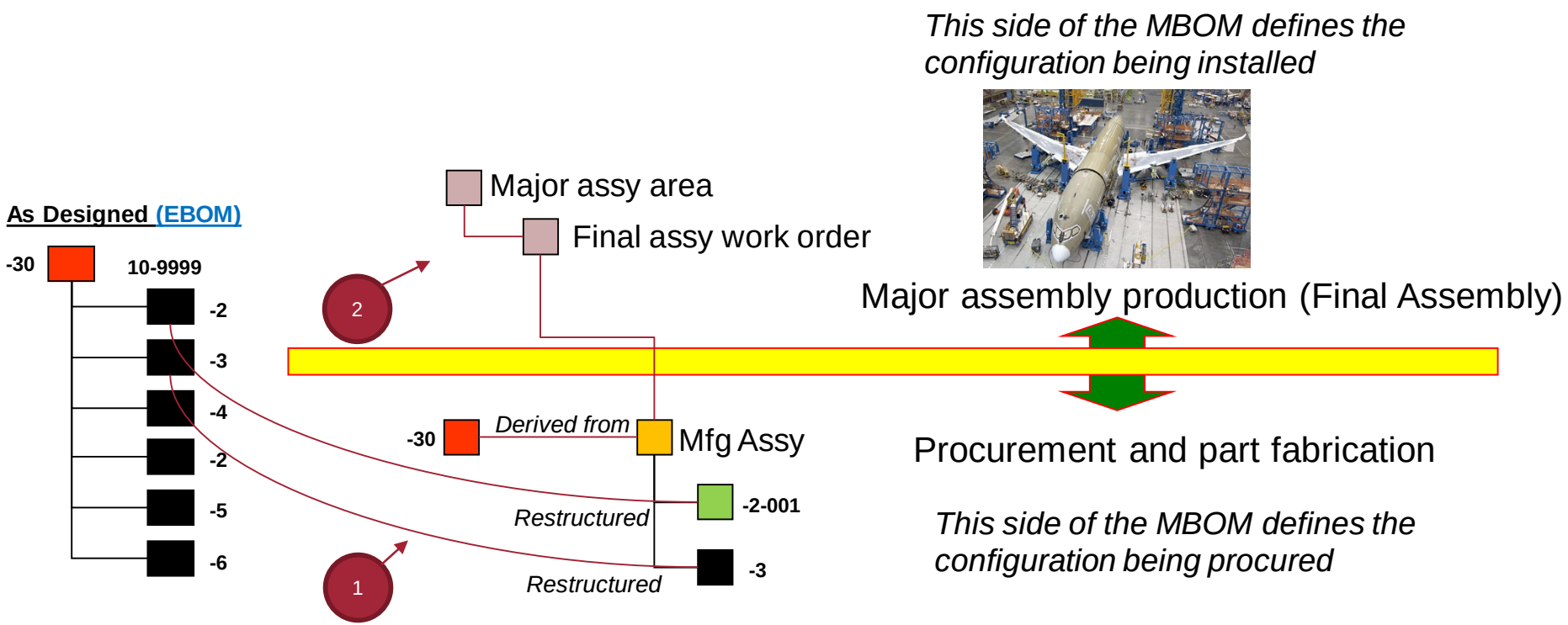
The EBOM baseline has six components, and there are two separate usages of the -2.

How to understand the following use case scenarios

MBOM assumptions / rules for scenario

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.

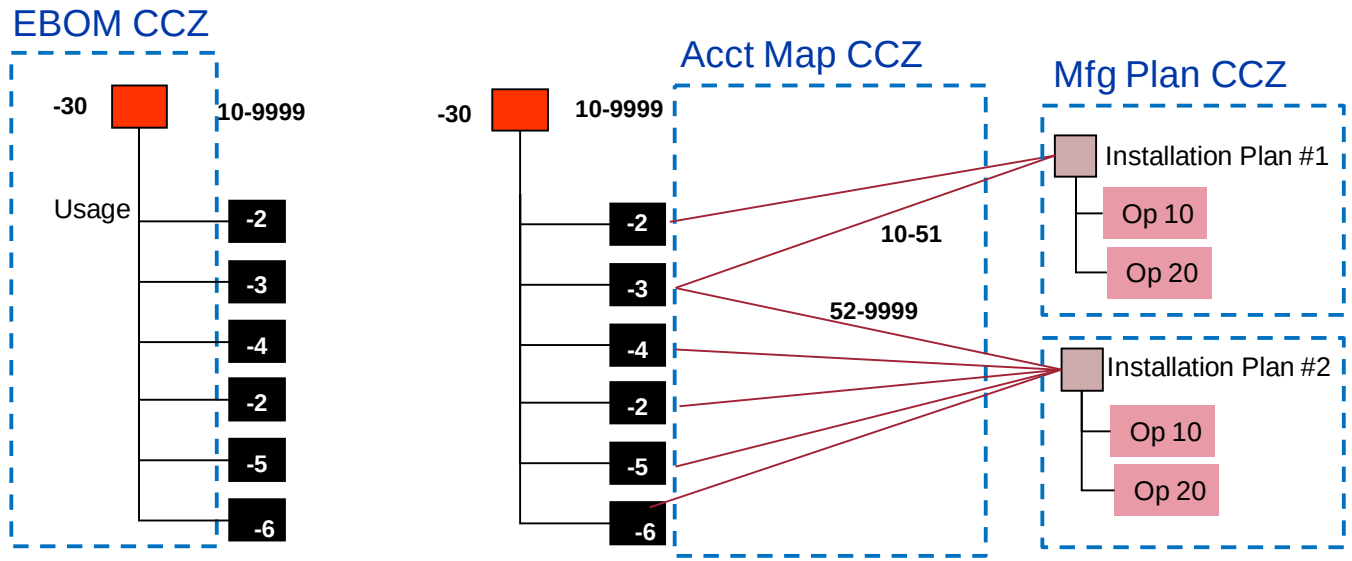


Configuration Control Zone

Concept

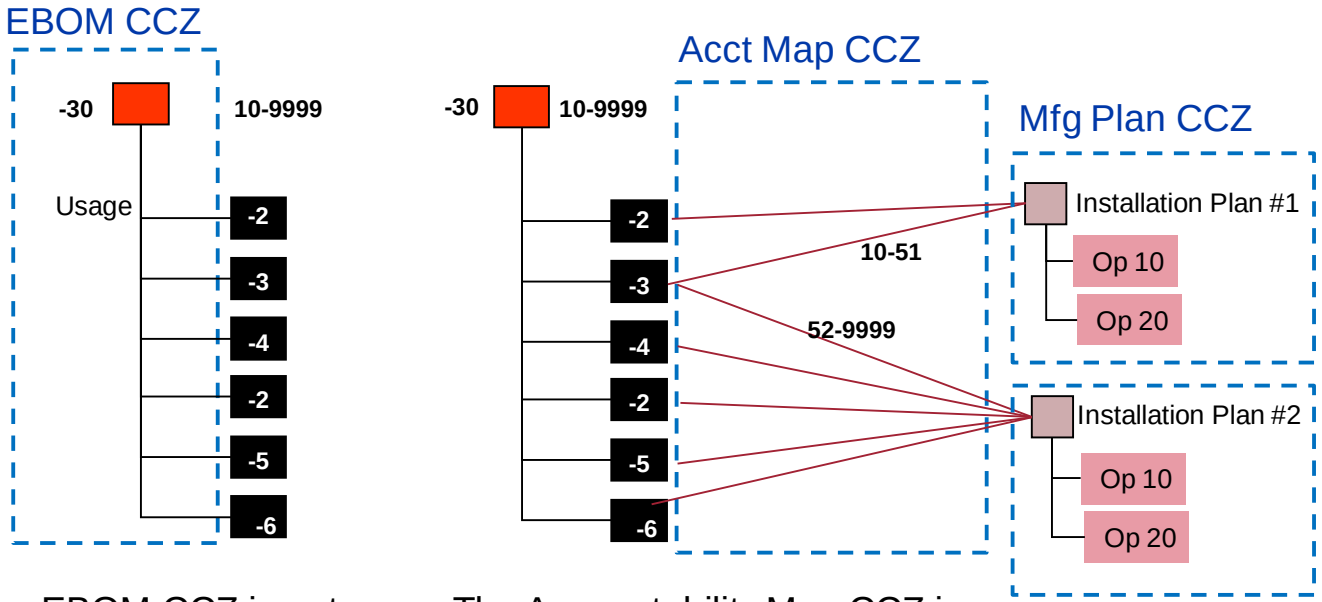
These examples will demonstrate how the EBOM is restructured into an MBOM with the configuration control zone (CCZ). The accountability map concept in these examples uses a separate CCZ from the engineering definition and the manufacturing plan revision. A key point is the need for **Three separate CCZs**.

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 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.



Configuration Control Zone

Key Assumptions



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.

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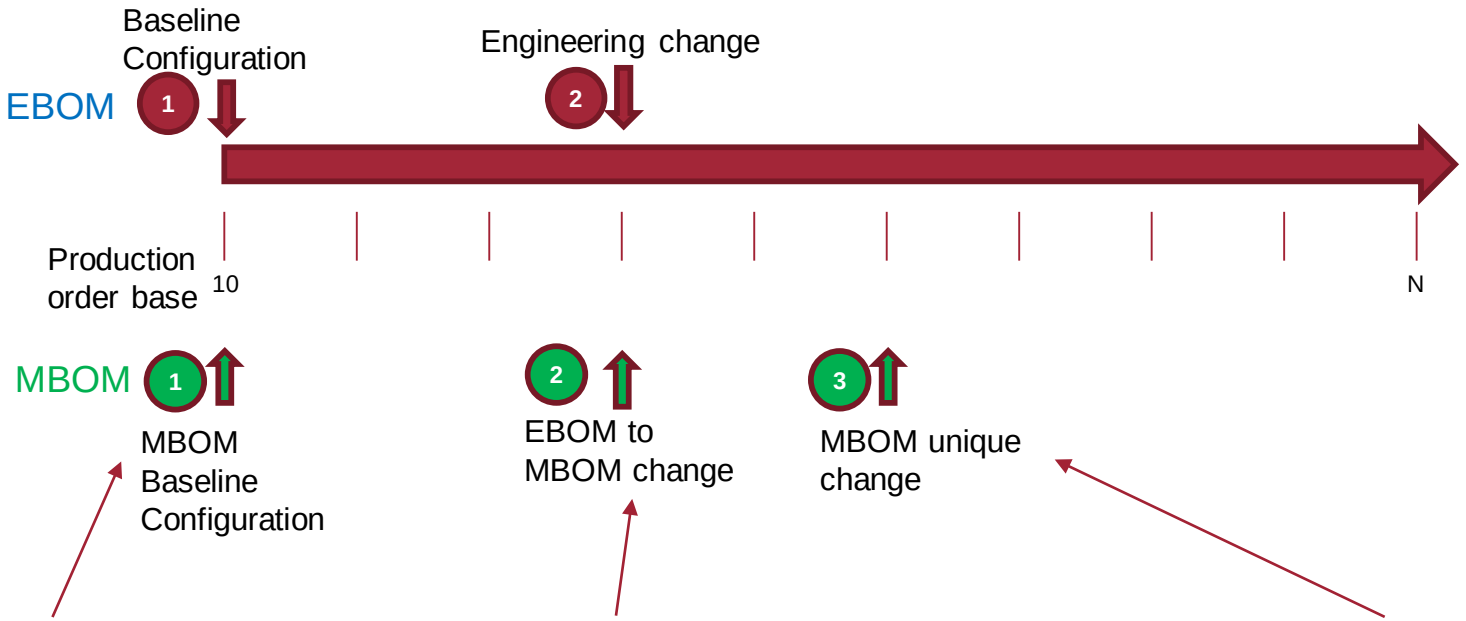
Accountability change scenario

Accountability becomes more complex as change is introduced. The following scenarios demonstrate the complexity using a change time line against the BOM structures.



Establish the baseline configuration for both EBOM and MBOM

Demonstrate accountability with EBOM change evolution

Demonstrate accountability with MBOM unique change evolution

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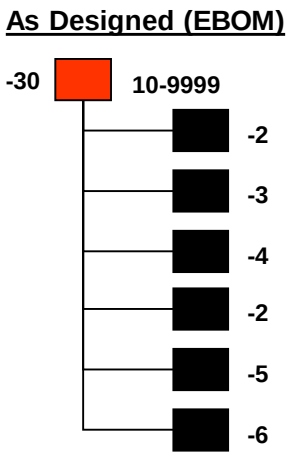
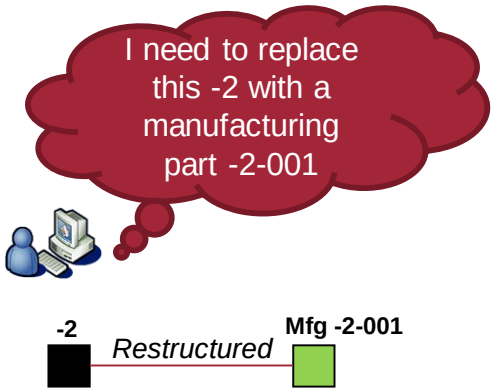
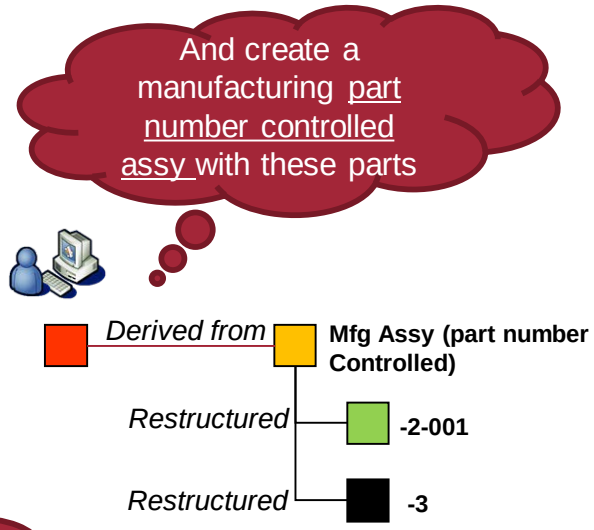
Accountability change scenario



Step 1: Deviation 1 for procurement



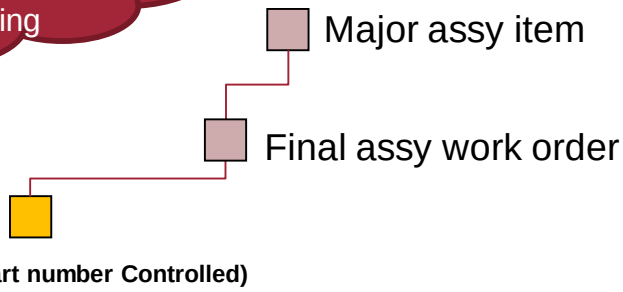
Step 2, Deviation 2 for procurement



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 3: For Final Assy

Step 4: Consume the MBOM items into the final assy plans



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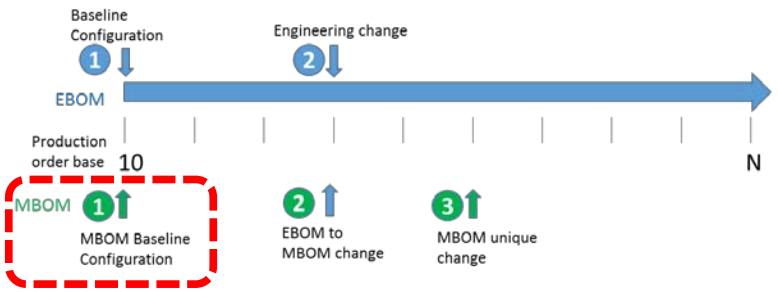
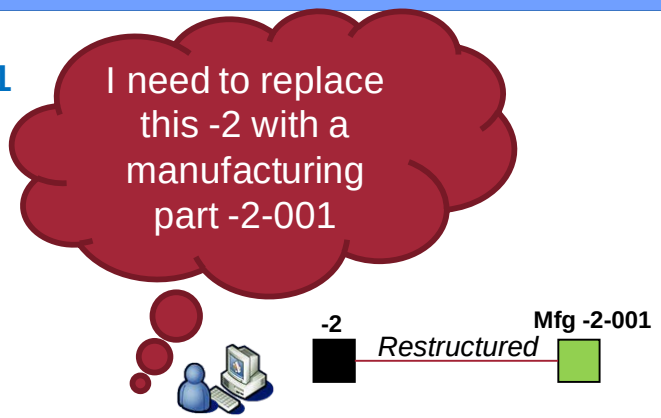
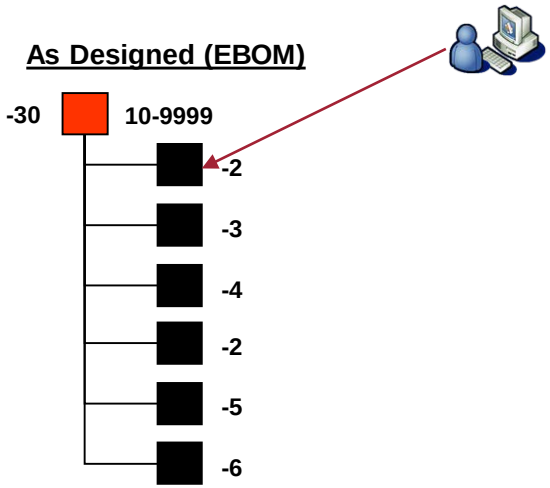
Accountability change scenario: Step 1



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.

As Planned (MBOM)

Baseline Scenario: create the MBOM for procured parts.

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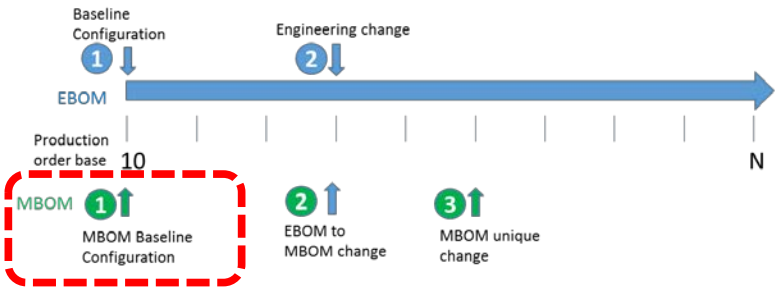
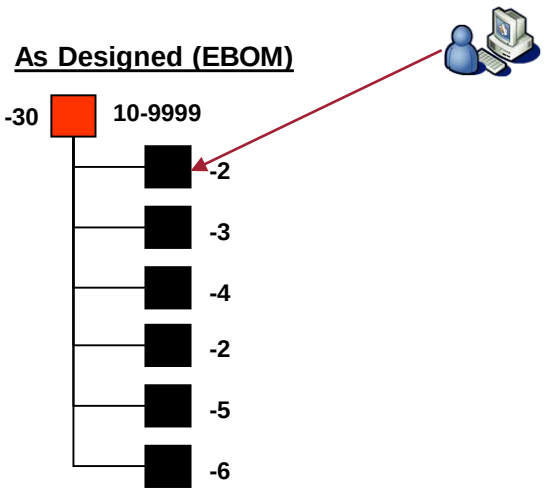
Accountability change scenario: Step 2



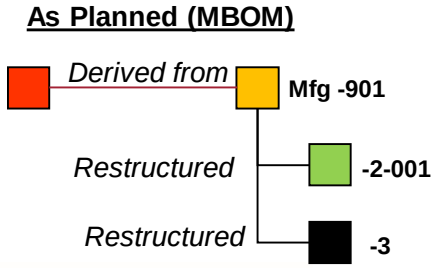
Baseline Scenario: create the MBOM for procured parts.



Step 2

And create a manufacturing assembly with these 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.



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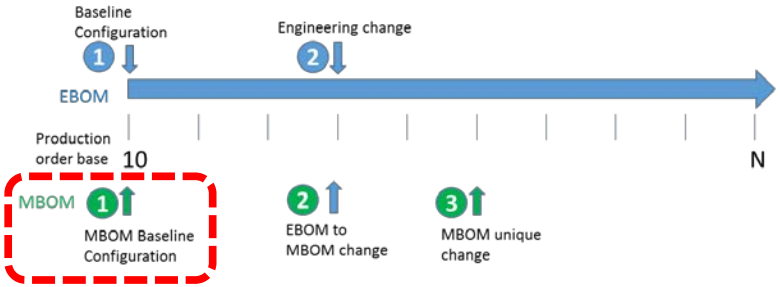
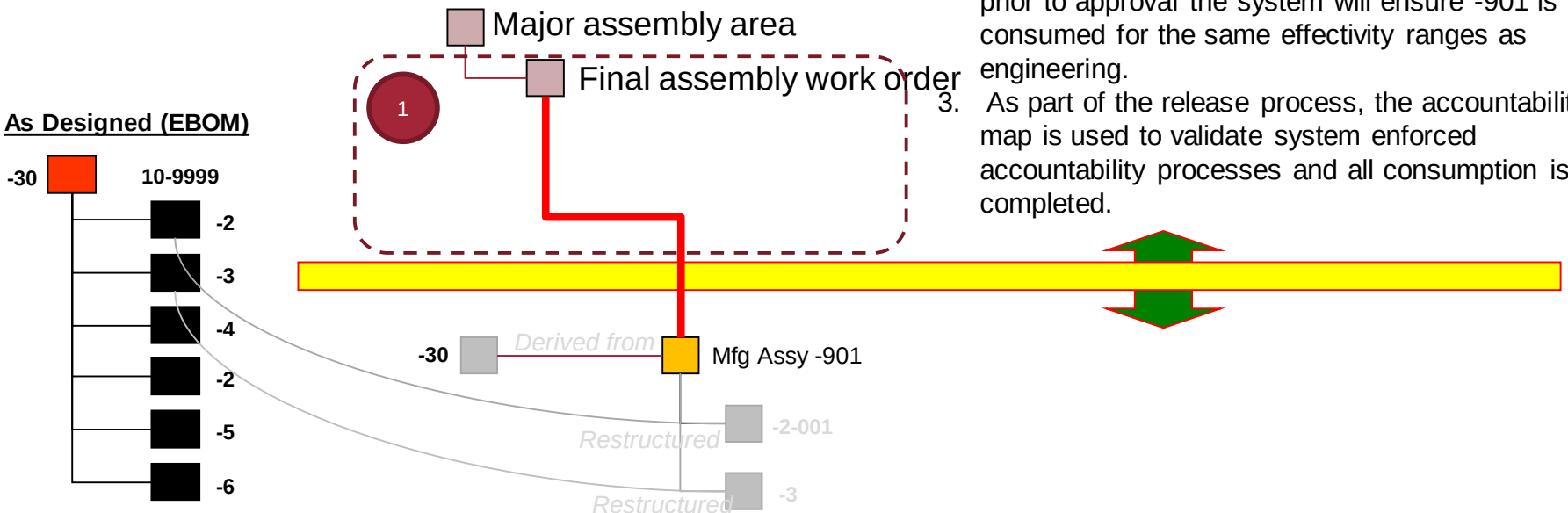
Accountability change scenario: Step 3

and consume the manufacturing assembly into the final assembly planning

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.



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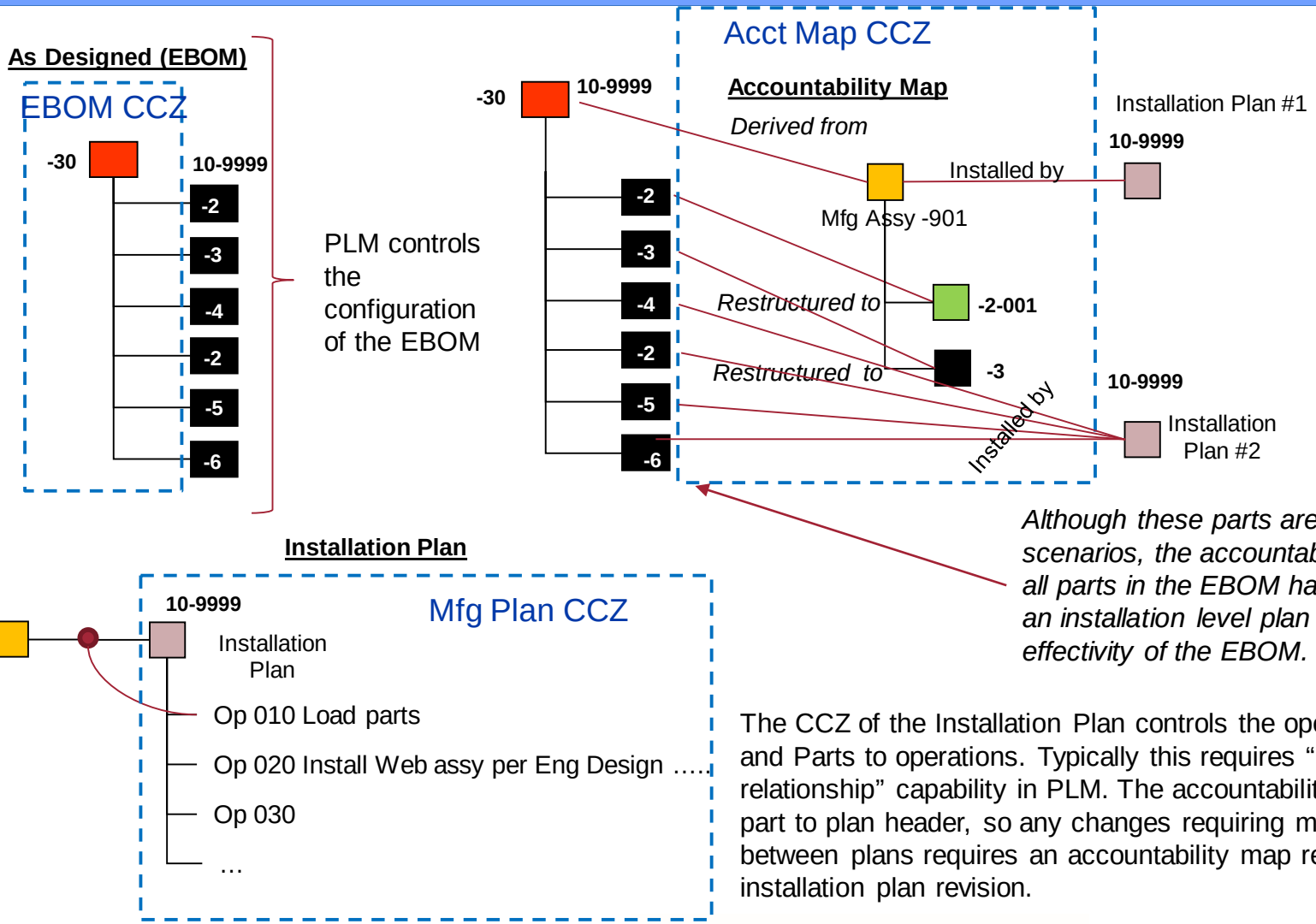
Accountability map view of scenario



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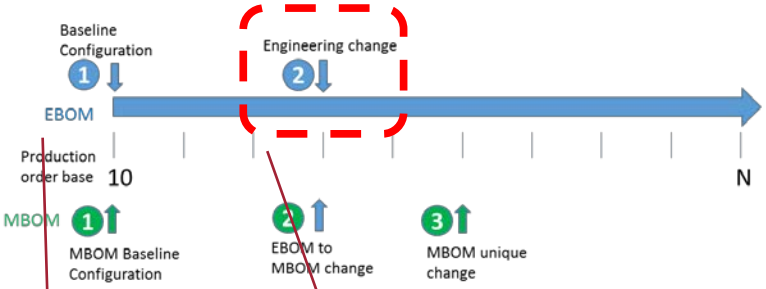
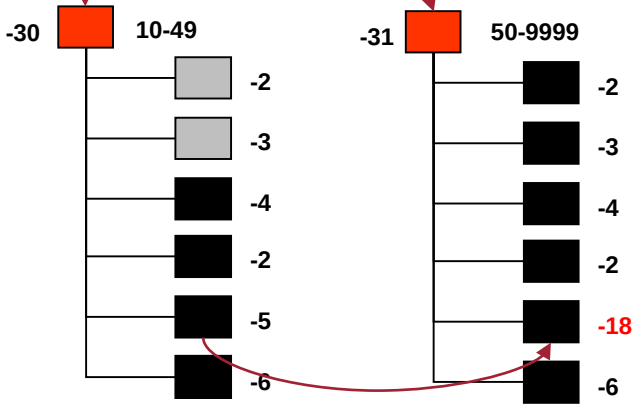
Engineering Change Scenario: Initial Conditions

So far, only a baseline is established between EBOM and MBOM.



Change Scenario: -30 is replaced by new -31



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)

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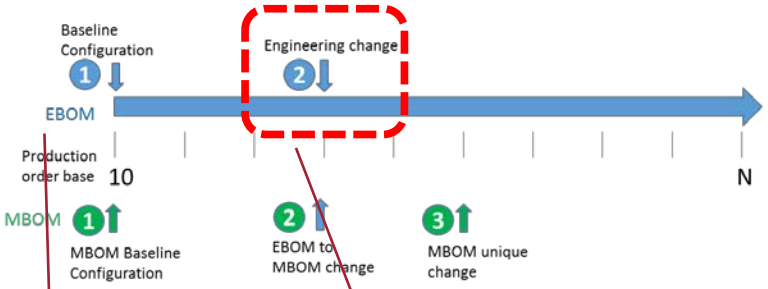
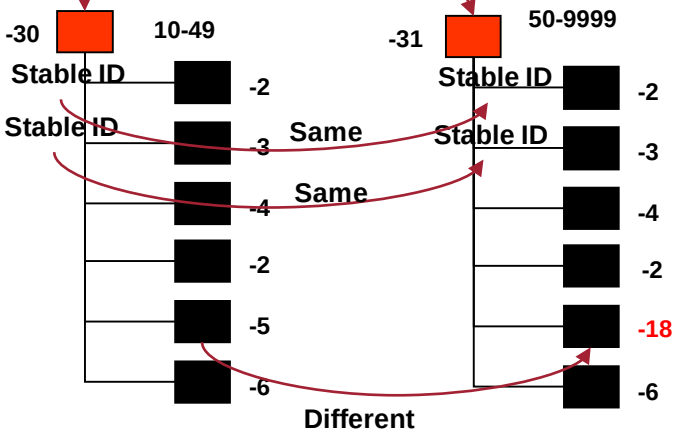
Engineering Change Scenario: EBOM Impacts

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.

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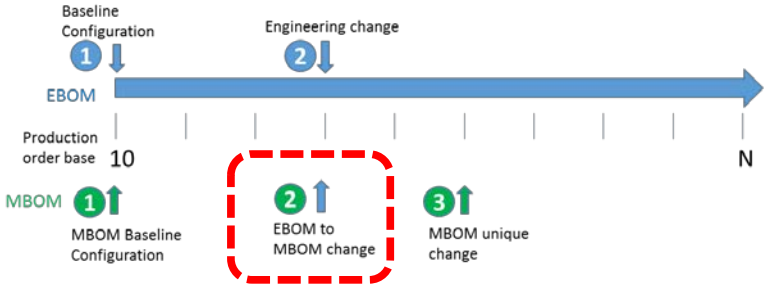
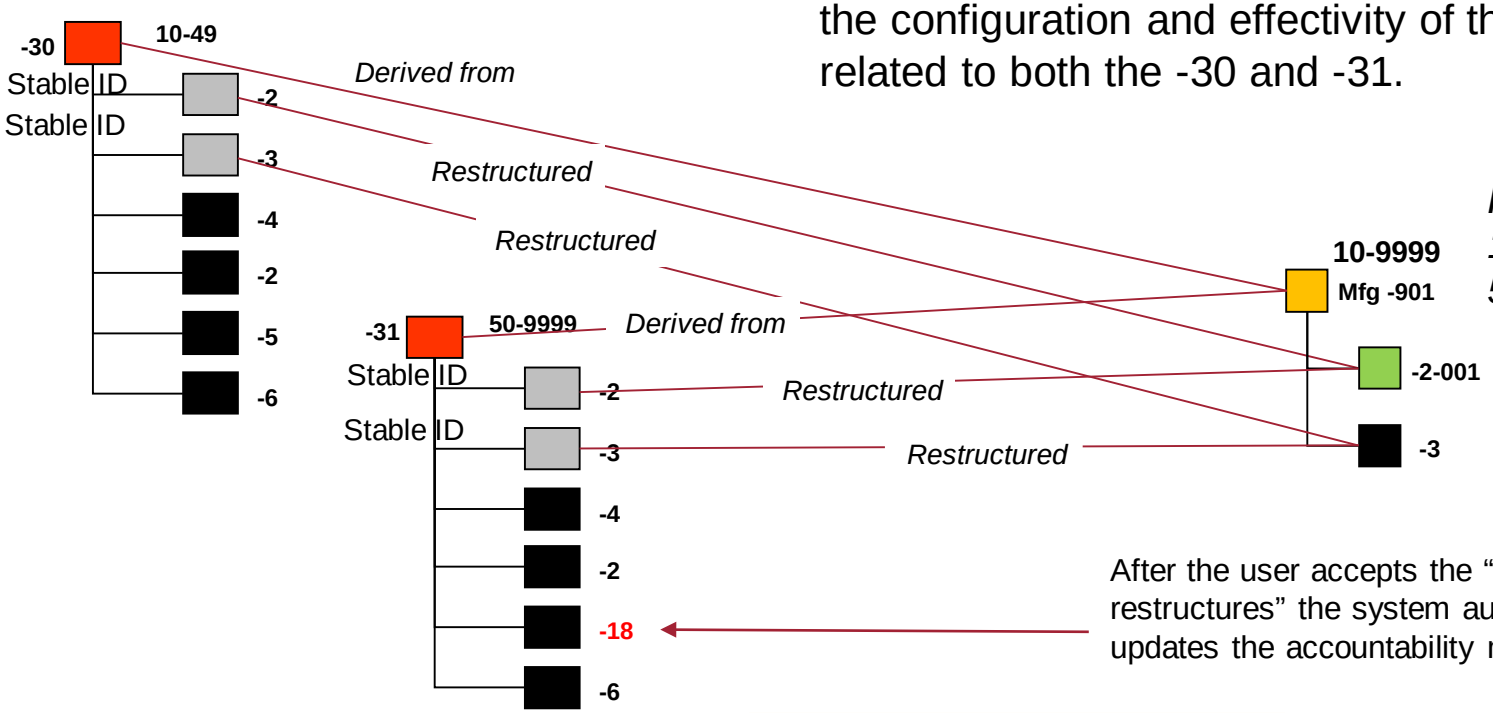
Engineering Change Scenario: MBOM Impacts



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.

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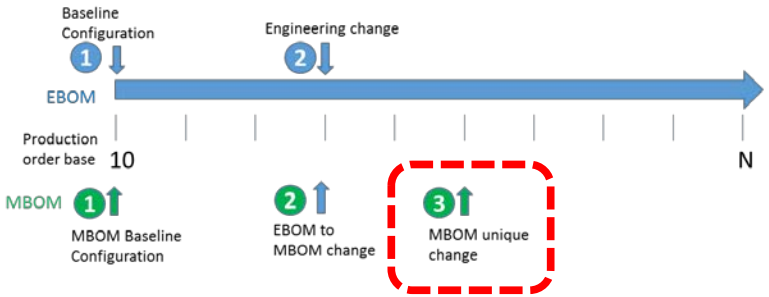
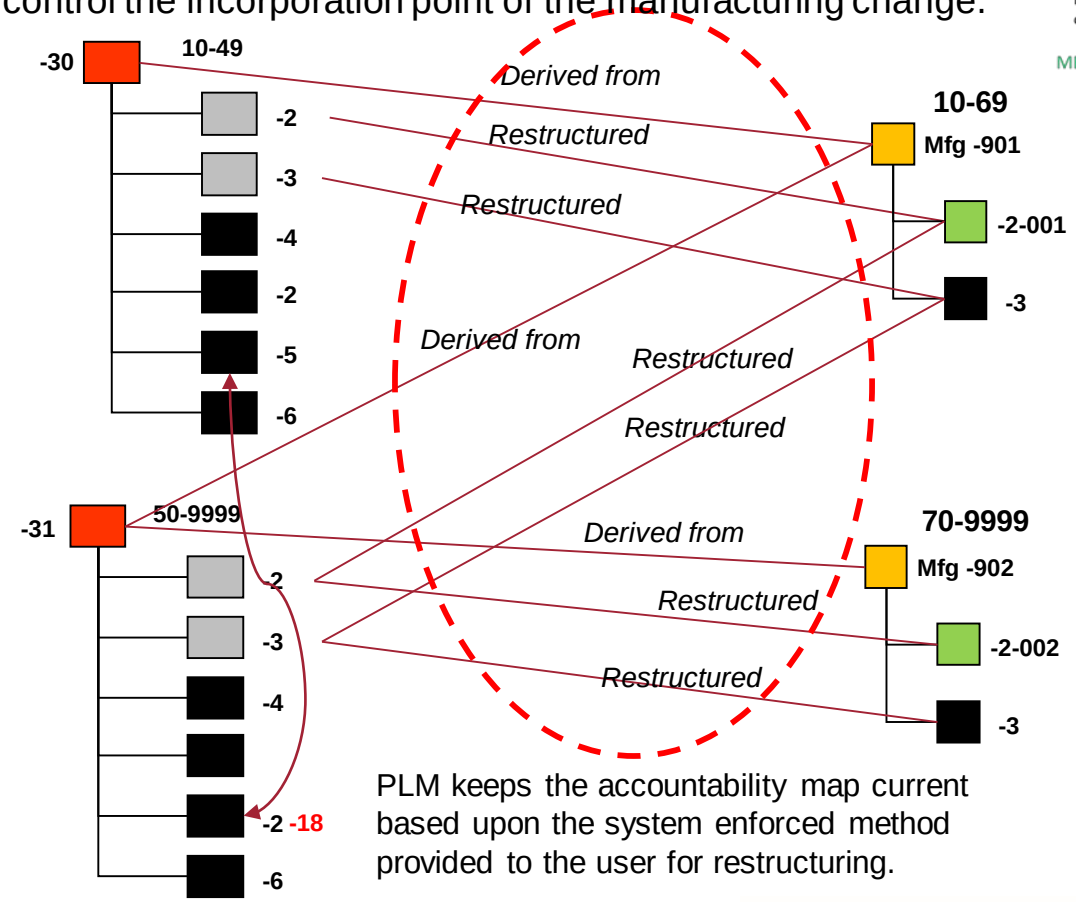
Manufacturing Change on Engineering Change Scenario

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.





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

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*

- **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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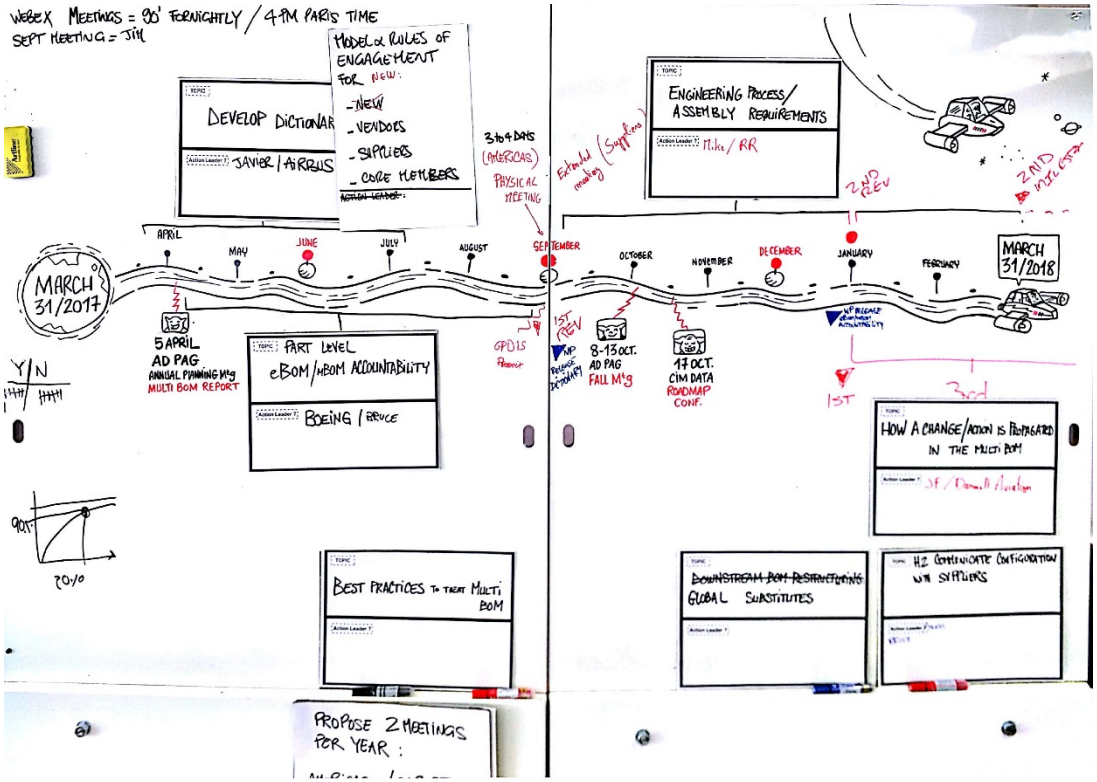
Next Steps

- 2nd workshop planned in Seattle, WA on September 25th - 28th
- Potential additional workshops in 2018.



Thank You

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Team Roster

Multi-View BOM				
Members	Benoit Plante	Airbus	benoit.plante@airbus.com	Team Leader
	Javier Reinés Palao	Airbus	francisco.reines@airbus.com	Deputy Team Leader
	Pepe Chulian	Airbus	pepe.chulian@airbus.com	SME
	Kenny Swope	Boeing	kenneth.a.swope@boeing.com	Boeing Coord.
	Bruce Hiebert (informal team leader)	Boeing	bruce.hiebert@boeing.com	SME
	Alek Przbylo	Boeing	aleksander.przybylo2@boeing.com	SME
	Ian Gilkerson	Boeing	ian.t.gilkerson@boeing.com	SME
	Pierre Barbeau	Bombadier	pierre.barbeau@aero.bombardier.c	SME
	Jean Francois Cugy	DS Aviation	Jean-Francois.Cugy@dassault-aviati	SME
	Fernando Lana	Embraer	fernando.lana@embraer.com.br	SME
	Flavio Pinho	Embraer	fpinho@embraer.com.br	SME
	Almir Alves	Embraer	almir.alves@embraer.com.br	SME
	Bob Fletcher	GE Aviation	bob.fletcher@ge.com	SME
	Mike Carlton	Ge Aviation	michael.d.carlton@ge.com	SME
	Cecil New	GE Aviation	cecil.new@ge.com	SME
	Dan Ganser	Gulfstream	dan.ganser@gulfstream.com	SME
	Greg Weaver	Gulfstream	Greg.Weaver@gulfstream.com	Mgt Direction
	Mike Clarke	Rolls-Royce	Mike.Clarke@rolls-royce.com	SME
	Chris Gregory	CIMdata	c.gregory@cimdata.com	SME and Support

Aerospace & Defense PLM Action Group

Founded in February 2014

AIRBUS

BOEING

BOMBARDIER
l'évolution de la mobilité

DASSAULT AVIATION

EMBRAER

GE Aviation

Gulfstream
A GENERAL DYNAMICS COMPANY

Rolls-Royce

SAFRAN

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

Aerospace & Defense PLM Action Group

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

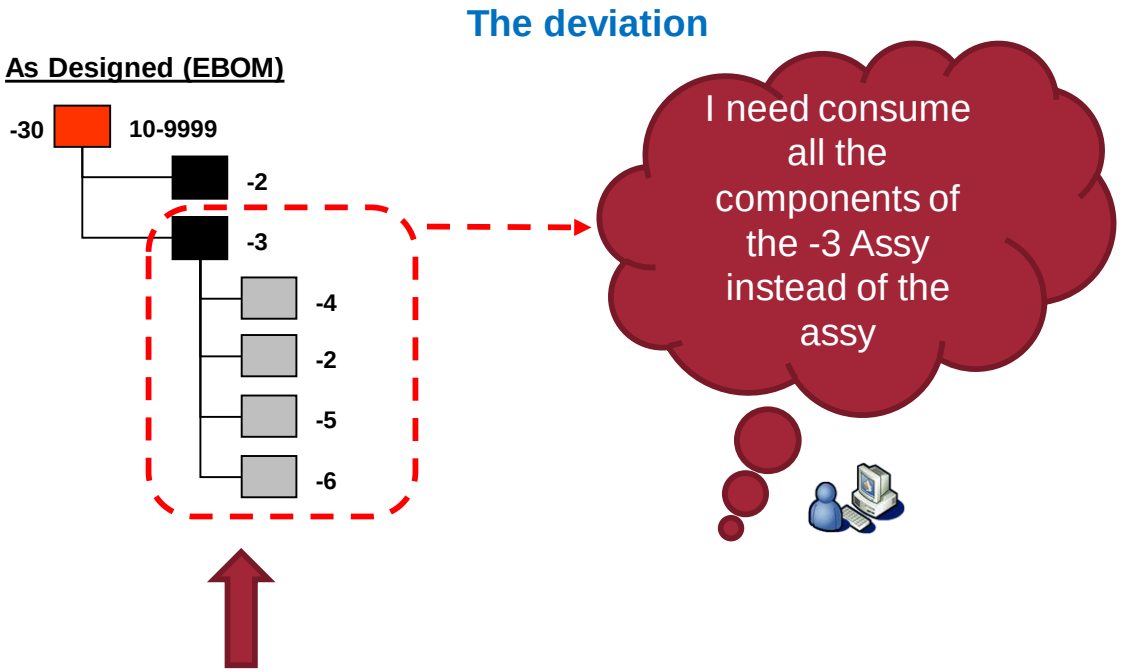
Internal Improvement: Specific actions members can take within their companies and supply chains

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

Multi-View Bill of Materials

Additional Restructure Types: Phantom Assembly



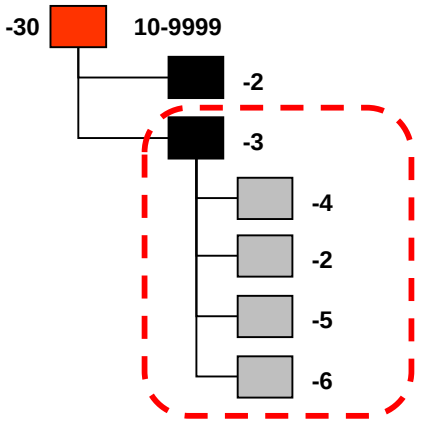
Installation planning scenario, not fabrication planning!

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

Multi-View Bill of Materials

Additional Restructure Types: Phantom Assembly

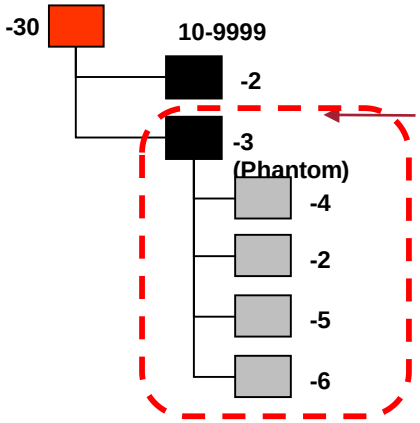
As Designed (EBOM)



The deviation

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

As Designed (EBOM)



Step 1

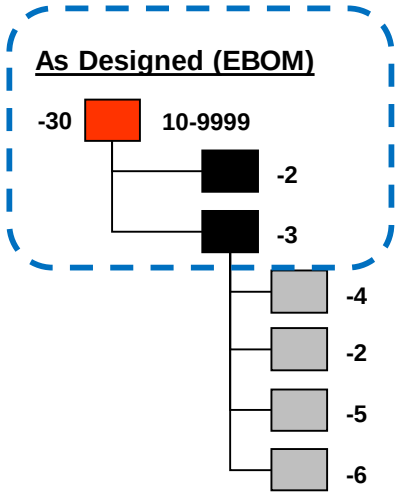
I need to identify the -3 as phantom and assign the components to two separates plans

Multi-View Bill of Materials

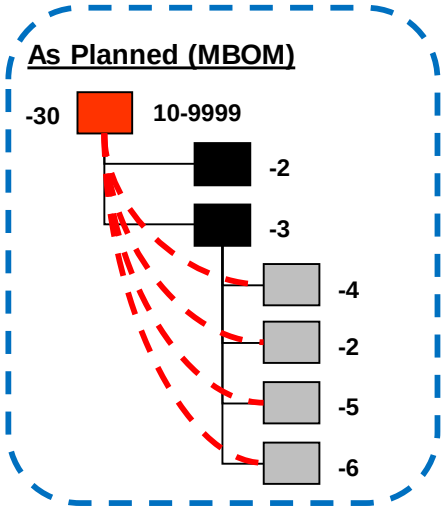
Additional Restructure Types: Phantom Assembly

Step 2: PLM accountability map update triggered by the restructure.

Accountability Map CCZ prior to phantom restructure



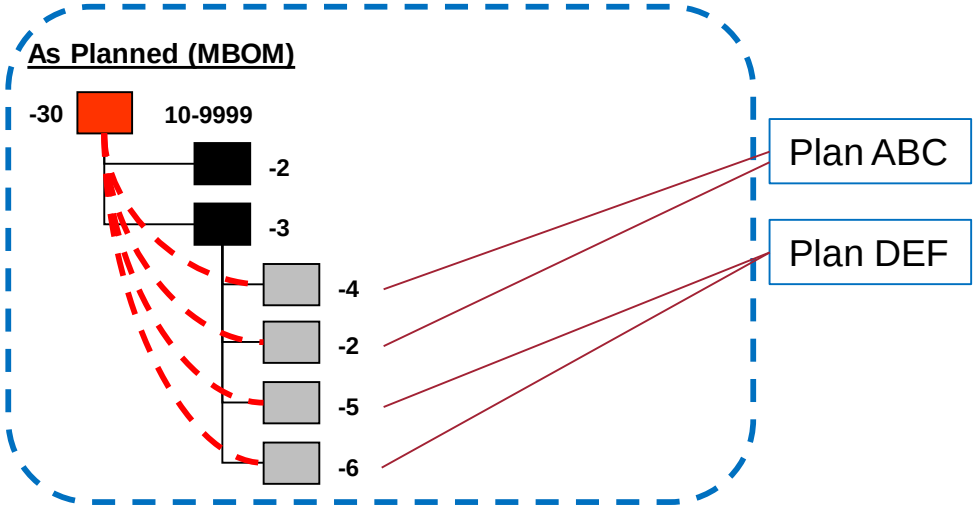
CCZ after phantom restructure



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

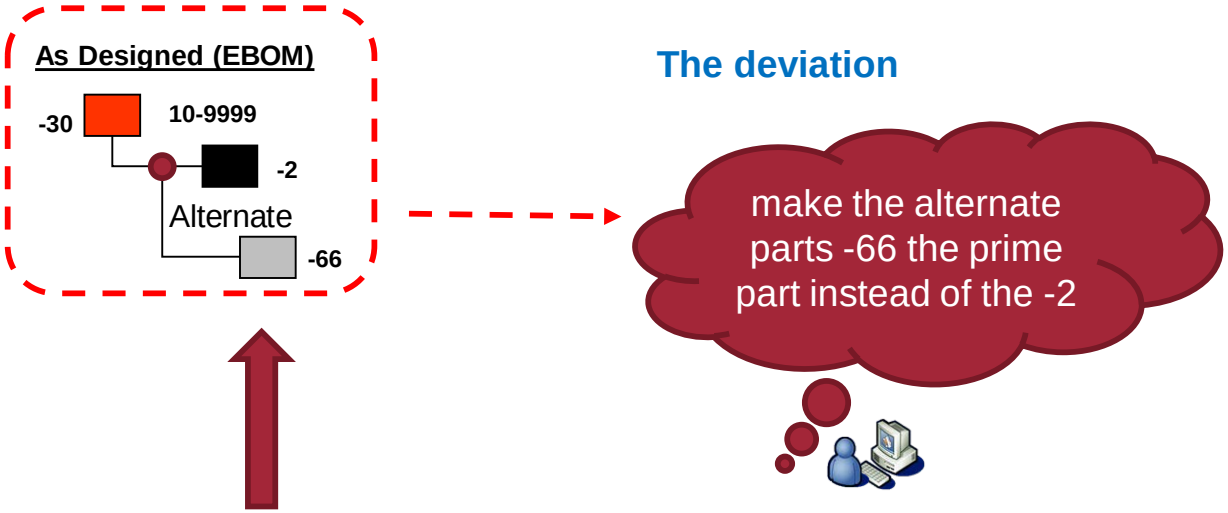
Accountability Map CCZ after phantom restructure



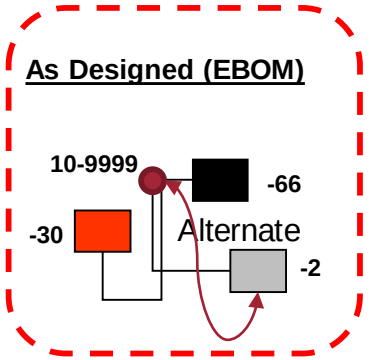
The accountability map ensures all components of the -3 are consumed into plans with effectivity checks and verification same as if they were components of the -30

Multi-View Bill of Materials

Additional Restructure Types: Alternate Parts

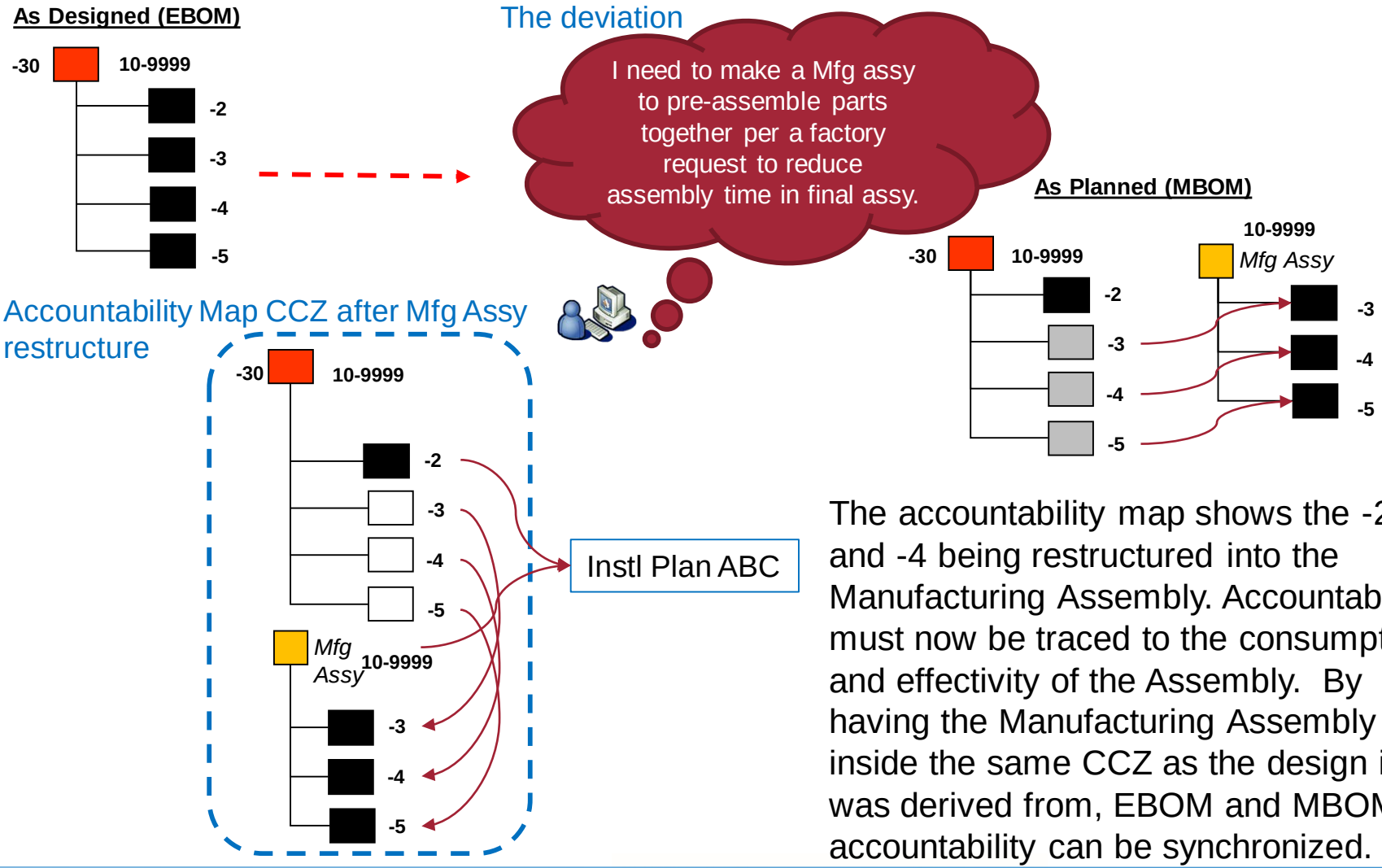


Note: the accountability map does rules do not need to account for alternate parts in the BOM. Only the Prime parts in the BOM are included in the accountability map rule set. To make this switch between prime and alternate, the MBOM needs to flip between prime / alternate relationships.



Multi-View Bill of Materials

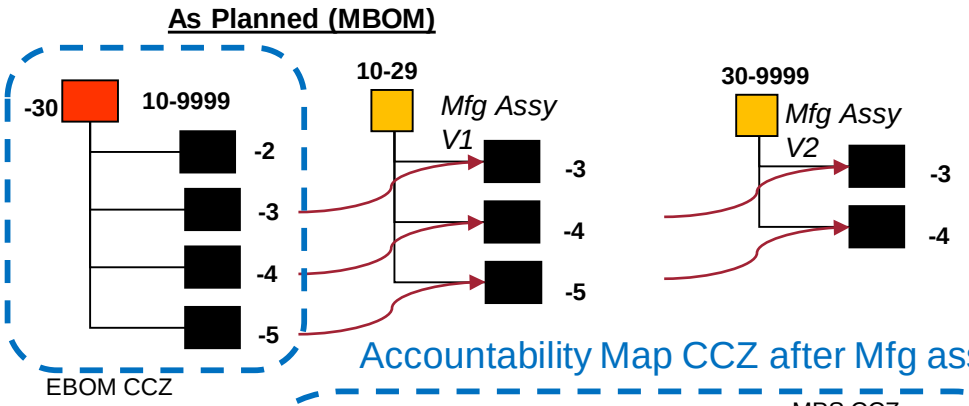
Additional Restructure Types: Manufacturing Superset Assemblies



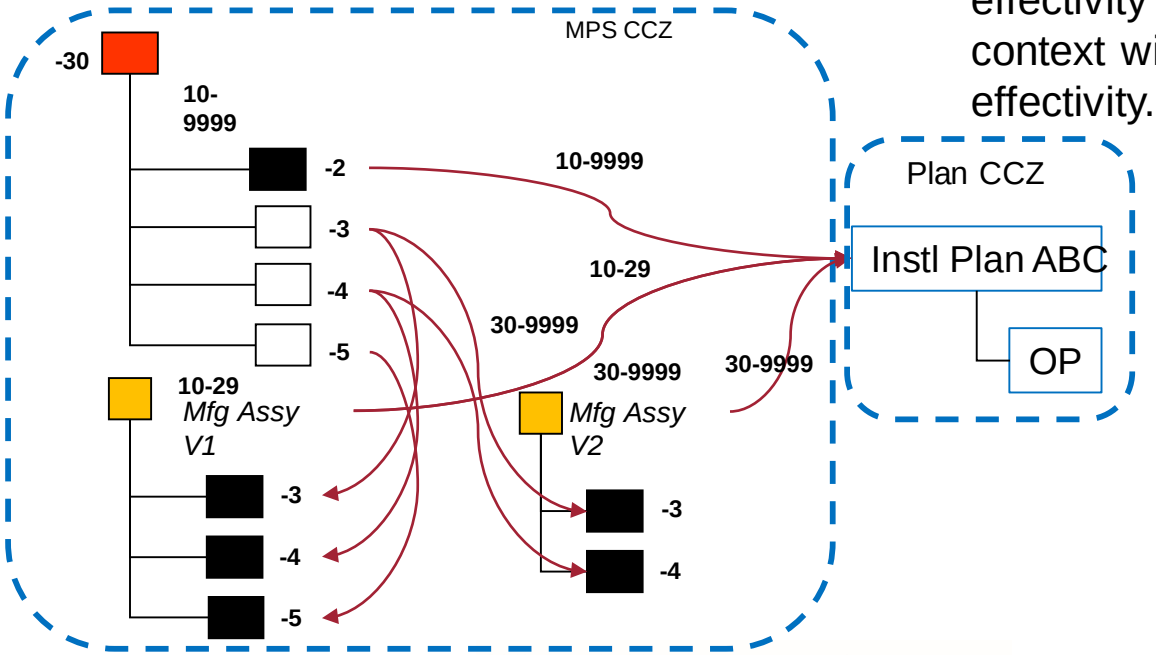
The accountability map shows the -2, -3 and -4 being restructured into the Manufacturing Assembly. Accountability must now be traced to the consumption and effectivity of the Assembly. By having the Manufacturing Assembly inside the same CCZ as the design it was derived from, EBOM and MBOM accountability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

Multi-View Bill of Materials

Additional Restructure Types: Manufacturing Superset Assemblies



Accountability Map CCZ after Mfg assy restructure



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.