

The Digital Thread Beyond (Product Engineering) and Back

New Program Requirements are dictating the creation and management of the "Digital Twin"

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GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2018



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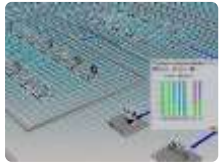
BOEING



iBASEt: Your Partner for Success



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- End-to-End digital integration of engineering and change control across the value chain
- Well defined Out-of-the-Box best-in-class processes, get up and running quickly
- Integrated Quality Management across Manufacturing Value Chain



- Only vendor solely focused on solving complex manufacturing and sustainment issues
- Professional Services team: 20+ years of Complex Mfg & MRO Operations experience
- Partner Network of global system integrators to help accelerate roll outs



- 60,000 Solumina users
- 80% of Leading Complex Manufactures have chosen iBASEt
- 30 years of organic growth through Customer Success – not – M&A

The Solumina software solution suite is designed to make **highly complex OEM and maintenance enterprises simple**, combining, in one suite a **MES, QMS, SQM and MRO**

- Easily integrated to the CAD, PLM, and with the ERP
- Preconfigured and easy to implement (“**Out Off The Box**”)
- Offering easy-to-use graphical interface
- Built according to the “lean” philosophy

+ of 150 factories and +60.000 users in the world work with Solumina



Our Highly Complex Manufacturing Customers



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Aircraft Components



Airframe Assembly



Military & Classified Weapons



Space Products



Industrial & Fabricated Parts



Commercial & Military MRO



Medical Device & Equipment



Naval Components



3 Percent

That's how much of a **Complex Discrete Manufacturer's revenue** doesn't make it to their bottom line.

Why are Executives Rarely seen getting excited about wasting 3 percent of revenues?

- Those dollars are rarely reported as waste.
- The more profitable a manufacturer is, the less it realizes that money is being wasted.
- Entire management practices and methods characterize these as Costs (The Cost of Doing Business)
- What we often hear early in the discovery:
 - “This is what it costs to Design, Plan and Execute at our company”
 - “We are world-class leaders in quality and efficiency for our industry”

The Digital Thread - Definition

In Brief, the Digital Thread represents the sum of all model data, product structure data, metadata, effectivity data, process definition data including supporting equipment and tools that are **DIGITALLY LINKED** together to form a single, contiguous definition of all value-added decision made during the definition of a product, its configuration, manufacturing and repair processes, logistics (vendors and subs) and operational support (PBL).

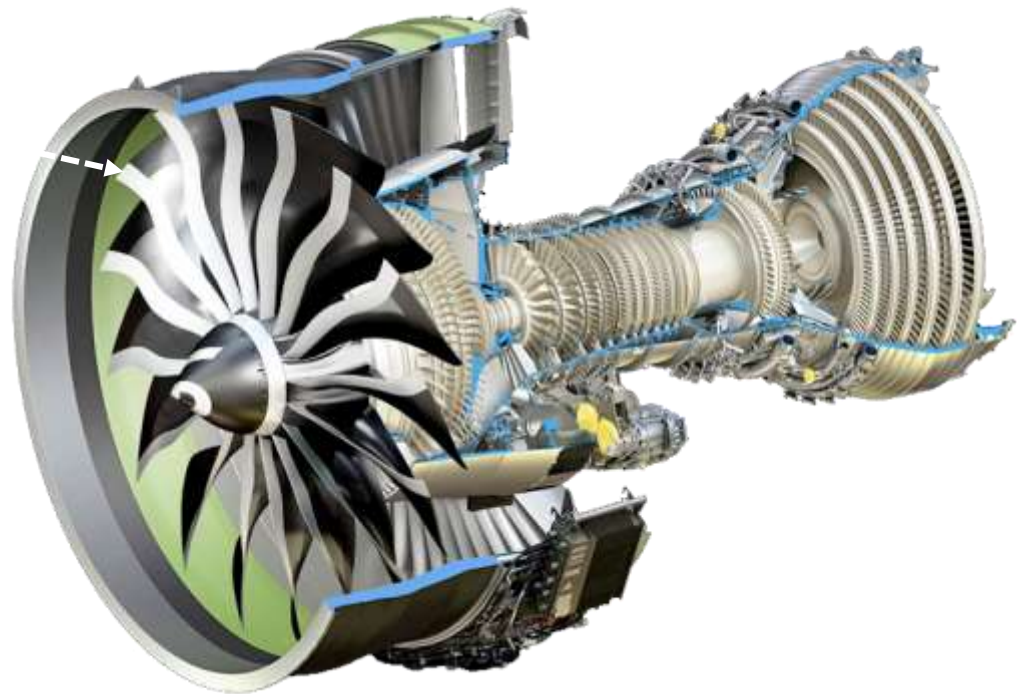
WHAT IS THE KEY TO THIS DIGITAL THREAD LINK?

THE CAD ID!

de7a8e65-ff17-447a-8b33-7a27e4f37bac

We Fetch and store it
for every Item listed
in a Bill of Material

The CAD ID is the
backbone of the
digital Thread!



WHAT DOES A DIGITAL THREAD COMPLIANT BOM LOOK LIKE?

<u>PART NUMBER</u>	<u>REV</u>	<u>BOM LINE</u>	<u>CAD ID</u>	<u>...</u>
4545-24313-1	F	001	de7a8e65-ff17-447a-8b33-7a27e4f37bac	
4545-24313-1	F	001	84365289-16c9-4621-bb20-346ffd81bd82	

WHAT DOES A **NON** DIGITAL THREAD COMPLIANT BOM LOOK LIKE?

<u>PART NUMBER</u>	<u>REV</u>	<u>QTY</u>	<u>BOM LINE</u>	<u>...</u>
4545-24313-1	F	2	001	

The Digital Thread–Data Model

- What Data Categories Make up the Digital Thread?
 - Part Numbers
 - 3D Models
 - Surfaces, dimensions, tolerances, datums,
 - Metallurgy, hardness,
 - Metadata (DFMEA, key characteristics, control limits)
 - Item Master Data
 - Authorize Sources
 - Inventory Locations, levels, replenishment methods
 - Bills of Materials, effectivities, options and features
 - Bills of Processes (Fabrication, Assembly, Integration, Test)
 - Service Intervals
 - Much, much, more...

WHAT is a PLE?

A PLE like Solumina enables:

DIGITAL THREAD COMPLIANT Process Definition, Manufacturing and MRO Execution, Defect Management, Engineering change and Supply Chain Management throughout the life of the Program and Units



Where does Data get Defined?

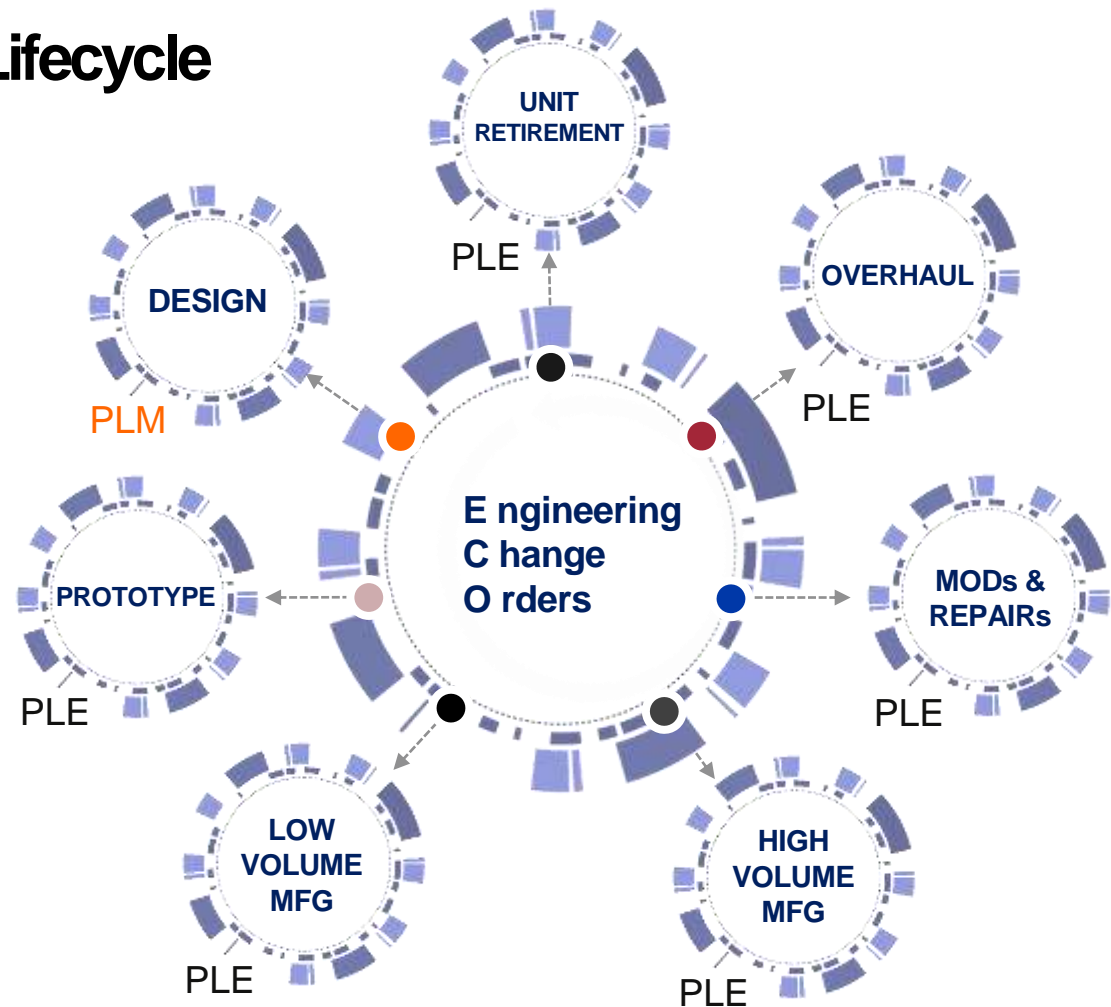
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The Complete Product Lifecycle from PLM to PLE

Throughout the product lifecycle, key Value-Added elements are defined and inserted into the product / process definition.

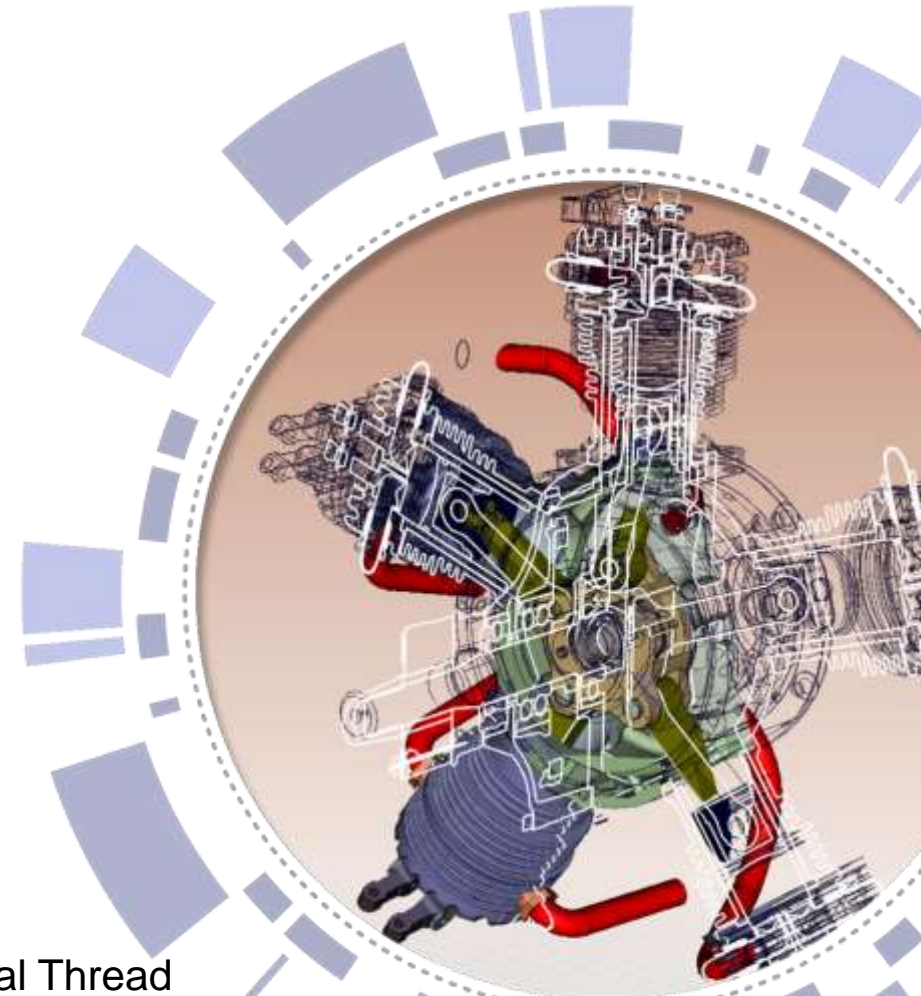
Anywhere this data is defined too late, there is a cost, a risk and a quality impact

Anywhere this data is copied, transcribed or re-interpreted, there is an even higher risk and potential quality impact!



Design Value Added Data

- 3D Modeling
- Virtual Assembly
- Process Modeling
- Engineering Bills of Material
- Quality Control Plans

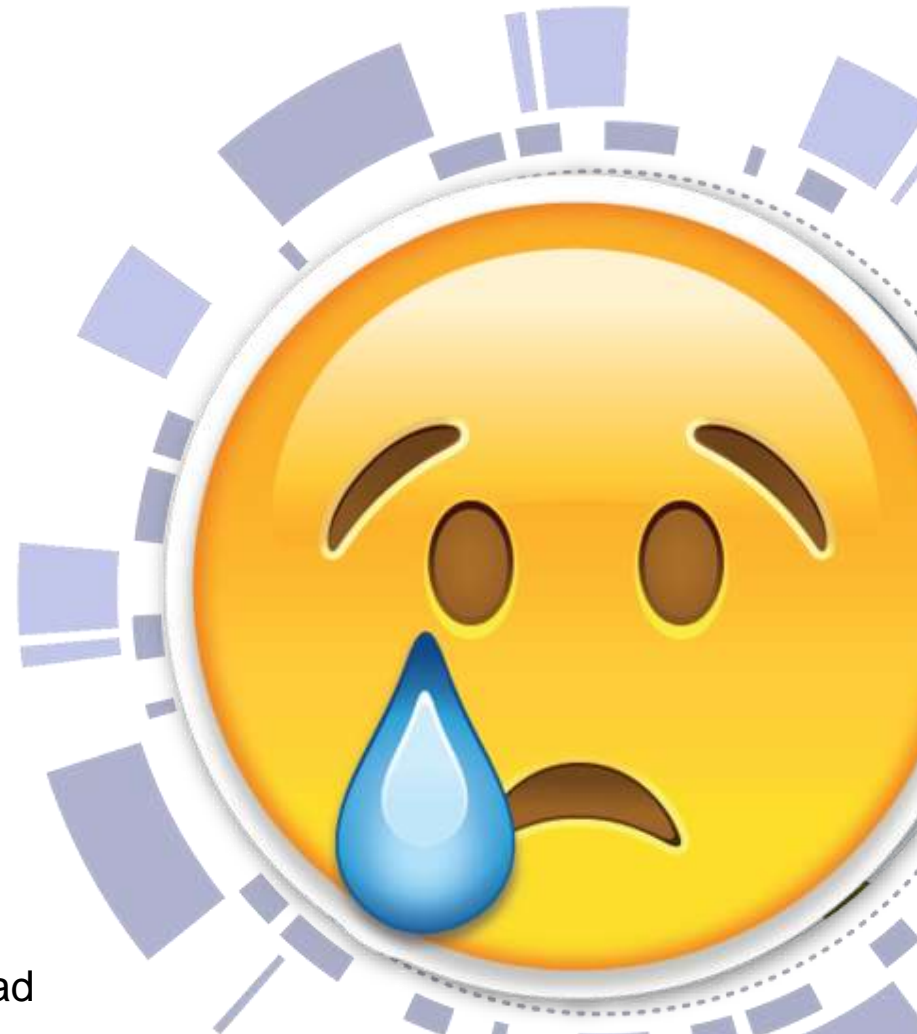


ORANGE items are commonly on the Current Digital Thread

Production Value Added Data

- **Model** / Drawing - Step Views
- Detailed Work Instructions
- Operationalized Part Lists
- Build Control Sequences
- Traceability Data Req's Per Contract
- Test Steps and Signoffs Per Contract
- Authorized Supplier Lists & KPIs

ORANGE items are commonly on the Digital Thread



What's the risk?



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Why should we change? What's the risks?

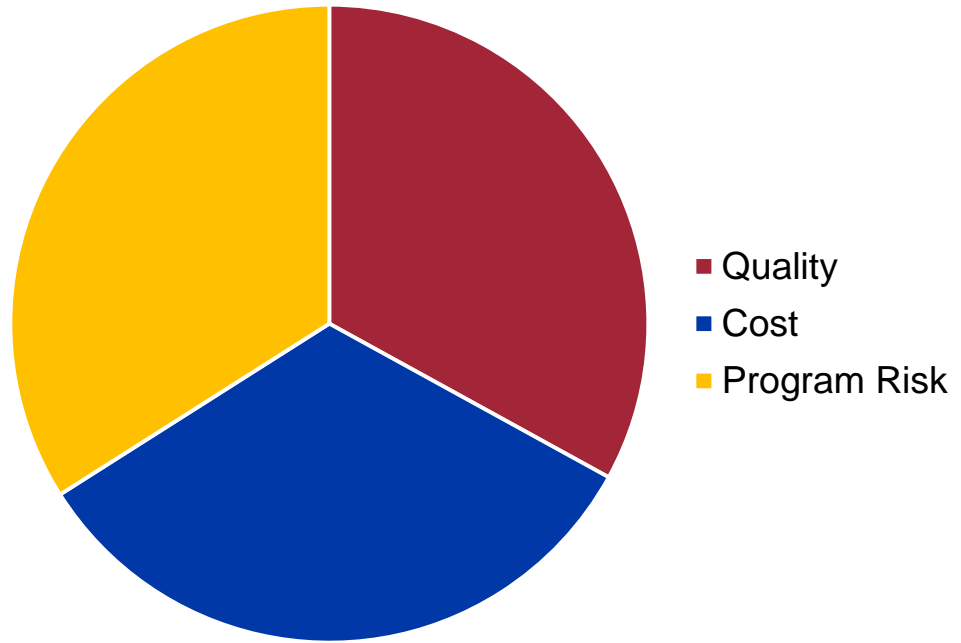
Model Design	E-BOM	M-BOM	Process Plan	Work Orders (WIP)	Finished Goods	Customer Units
Value Added Tasks:						
3D Models 3D Structure(s) TM Effectivities Item Master Create / Assign GD&T data (PMI)	Assigning Basic Alts & Subs Assigning Make-buy Assigning Contract requirements Selecting Vendors Assigning Macro Lead Times Selecting Materials Assigning Macro Planned Costs Assigning Work Locations	Yield Rates Phantom Flags Location Based Alternates Installation Sequence Units of Measure / Conversions	Operations & Steps MBOM Operationalized Work Center Assignments Time Standards Tool Usage Process Spec Assignment Serialization Rules SPC Rules Signatures & Inspection Reqs Calculations Precedence Rules Standard Rework Branches Operation Effectivities	Quantites & Dates Priorities Team Assignments Material Issues Tool Issues Traceability Data Collection Sign-offs & Inspections Move from WIP to FG	Sales Order Complete UID Publish Sell-Off	Walk-Thru & Acceptance
Potential Non-Value-Added Tasks:						
	Transcribing BOM Components Assigning TM Effectivity Assigning Reference Designators Assigning Weights	Transcribing BOM Components Assigning TM Effectivity Assigning Reference Designators Assigning Weights Assigning Alts & Subs Assigning Make-buy Assigning Contract requirements Selecting Vendors Assigning Macro Lead Times Selecting Materials Assigning Macro Planned Costs Assigning Work Locations	Step Visuals Upper/Lower Limits Component TM Effectivities Assign Basic Alts & Subs Assign Phantom Flag Location Based Alternates GD&T data (PMI) Yield rates Installation Sequence Units of Measure / Conversions	Process/Part Alterations Parts List Creation Paper Work Package Create Manual Data Collection Manual Part/Tool Serialization manual Signatures Drawing Lookups Process Spec Lookups Manual Calculations Manual Red Tags Manual Precedence Control Manual Operation Activation Manual Operation Reconciliation	ECO Rework As-Built/DD250 Create UID Data Collect Paper Packet Audited Paper Packets Scanned Paper Packets on CD Red-Lines Audited Non-Conformances Audited UID Labels Audited DCMA Audits	Squawks Travelled Work Complete ECO Rework
Risks:						
L - Model Errors L - Structure Errors L - TME Errors M - Duplication of IM Data L - Overly Tight Tolerances M - Overly Loose Tolerances H - Raw Materials Errors	L - Alternates Errors M - Effectivities Errors M - Quantity Errors	M - Alternates Errors M - Effectivities Errors M - Quantity Errors	L - Work Center Errors L - Time Standard Errors M - Tooling Errors M - Process Errors M - Signature / Inspection Errors M - Precedence Errors H - Access Rights Errors	L - Work Center Errors L - Time Standard Errors M - Stamp-Off Errors M - Data Collection Errors H - Tooling Errors H - Process Errors H - Signature / Inspection Errors H - Precedence Errors H - Access Rights Errors VH - Model Errors VH - Structure Errors VH - TME Errors	H - Raw Materials Errors VH - Model Errors VH - Structure Errors VH - TME Errors	VH - Raw Materials Errors VH - Model Errors VH - Structure Errors VH - TME Errors

What's Changed in Defense Acquisition Requirements

- Many new Programs now have Contract Elements that refer specifically to the delivery of a Digital or Cyber artifact that COMPLETELY describes the Model-Based as-Designed, the reconciled As-built (with necessary waivers) and the Quality history (including test results) of the asset.
- Gone are the days where delivering functioning hardware was the only trigger for payment.
- These Digital artifacts need to be created and validated in real-time as each vendor produces their sub-assemblies and as each facility performs the final integration.
- Within 5-7 years, we believe that all Major Defense Programs will have Digital-Twin requirements that make-up a important portion of the payment and Acceptance trigger.

Three Areas Affected by the Digital Thread

Remember
The 3% of Revenue
That never makes it to
The bottom line.



The Three Opportunities presented by the Digital Thread

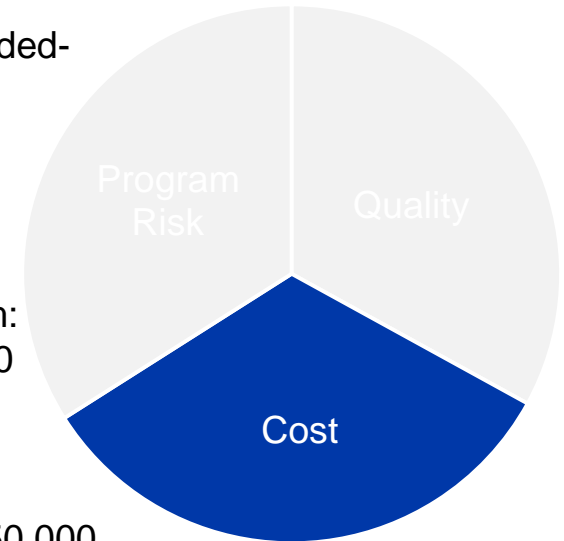
- Each element of the Value Stream where data is either:
 - Re-Invented
 - Re-Interpreted
 - Transcribed
- INTRODUCES AN OPPORTUNITY FOR DEFECT...
- If the defect is caught in –house, the impact is:
 - Dollars
 - Schedule
- If the defect is NOT caught in-house, the ESCAPE affects the program credibility and repeat unit sales



The Three Opportunities presented by the Digital Thread

- The Digital Thread introduces for the first time a framework of Value-Added-Sustainment:
 - Work Gets gone ONCE
 - Quality variances are resolved ONCE
 - Engineering Changes are processed ONCE
- Let's use an Example: Step by step visuals for a Major Defense Program:

• Quantity of Visuals for entire structure	=	150,000
• Avg. Labor Hours per Visual by Mfg. Eng.	=	1.5
• Avg. No. of Process / ECO Changes per Visual*	=	6
• Average Burdened Cost of Mfg Eng (\$/hr.)	=	67
• Cost of NOT having Visuals on Digital Thread**	=	\$ 90,450,000



* For life of Program

** Immediate Cost only, does not include Risk Cost of Quality cost due to increased opportunities for defect.

The Three Opportunities presented by the Digital Thread

- Even if Costs and Quality Rates were NOT an issue,
- A Program cannot afford any variation that will affect the program's ability to meet program milestone dates.
- Most programs have penalty clauses that can get triggered by :
 - Late milestone deliveries
 - Escape rates / Missing Traceability Data (UNKs)
 - Unit Commissioning dates
- **BOTTOM LINE:** Programs need stability and little to no process variability. Once a good decision has been made (Value-Added Content), it should be preserved.



Classifying your level of Digital Thread Adoption by Program

- F** – 2D Drawings, Paper Work Instructions, Manually generated Visuals, Separate Data Collection sheets, Separate Inspection Sheets, Receiving Inspection, Paper QA System, Paper As-Built Documentation.
- E** – 2D Drawings, **Paper on Glass** Instructions, Manually generated Visuals, Separate Data Collection sheets, Separate Inspection Sheets, Receiving Inspection, Paper QA System, Paper As-Built Docs.
- D** – **3D Model Drawings**, **Paperless Instructions**, Manually generated Visuals, Separate Data Collection sheets, Separate Inspection Sheets, Receiving Inspection, **Electronic QA System**, Paper As-Built Docs.
- C** – **3D Model views**, Paperless Instructions, **3D Derived Visuals**, **Integrated Data Collections**, **Integrated Control Plans**, **Supplier Source Inspection**, **Integrated QA System**, **Integrated As-Built Documentation**
- B** – **3D Model Views**, **3D Bills of Resources**, Paperless Instructions, **3D Derived Visuals**, **Integrated Control Plan**, **Integrated Sampling**, **Source Inspection**, **Integrated QA System**, **Integrated As-Built Docs**.
- A** – **3D Model Views**, **3D Bills of Resources & Bills of Process**, **Integrated Execution**, **Shop Quality**, **Supplier Source Inspection**, **As-Built Data** and **Process Capability Data** (Heat Maps) returned to PLM System.

Here's a Simple Matrix to determine the best path forward!

Grade/Action ▾	1	2	3	4	*
F	████████████████████				
E	████████████████████				
D	████████████████████				
C	████████████████████				
B	████████████████████				
A	████████████████████				██████████

The 4 Incremental Steps (Stages) to getting on the Digital Thread

- **Stage 1**
 - Item Master and Default 3D Visuals.
 - Engineering Bills of Materials.
- **Stage 2**
 - Engineering Changes.
- **Stage 3**
 - E-BOM to MBOM Management in Model Based Space.
 - Enhanced Engineering Changes.
- **Stage 4**
 - Process Management leveraging Model-Based Space for Visuals Creation.

Stage 1: Leveraging Item Master and BOM data in PLE

- You already have an item master that includes default model-based visual data that easily can be used for creating new annotations or model Views. The PLE stores those views directly in the PLM.
- Your Default Bill of Materials (E-BOMs or Combo E/M-BOMs already have most of the needed data for Manufacturing
 - Effectivities
 - Alternates
 - Phantoms
 - Standard positions (LIDs, SINS, Ref Des, Find Numbers)
 - Default BOM Model-Based Visual with Thumbnail.
 - CAD IDs (For Instance-based reconciliation)
- This BOM Data is reconciled to the Process Plans AND Unit Histories by The PLE.

Stage 2: Leverage PLM Engineering Change messages in the PLE

- Engineering Changes are difficult. They reach all over the Planning data and shop floor systems and never end... Mistakes are not only common, they are a virtual certainty.
- ONE Engineering Change can involve hundreds of discrete actions that need to affect some data, skip other similar data and all changes need to be traceable and auditable.
- Use the structured ECO Messages and Bill of Resource updates to allow the PLE to create a SCRIPTED list of changes for Process Plans, Work Orders, Inspection or Sampling Orders and Discrepancies.
- First Article rules will automatically be triggered by the Engineering change actions
- Employees will be individually alerted to any changes since their last completion.

Stage 3: Leverage your PLE Tools to Manage MBOM Creation and Reconciliation

- EBOM to MBOM Transformation is **the most costly source of Process Definition mistakes** in A&D manufacturing.
- Classical methods for creating and maintaining MBOMs provide little in the way of reconciliation to the PLM Model-Based data.
- EBOMS and MBOMS created from one another in the PLM tool maintain a traceability that is important for making revisions and evolutions less error-prone. The visual Model-based tools also make engineering changes across multiple MBOMS easier to deal with.
- The PLE reads the EBOMS and MBOM Headers and components including Instance-based data to ensure that we know the location of each CAD instance in the build process. This ensures that ECO changes affecting only partial quantities of a Part Number are properly processed.

Stage 4: Leverage your PLM data Links to facilitate Process specific visuals

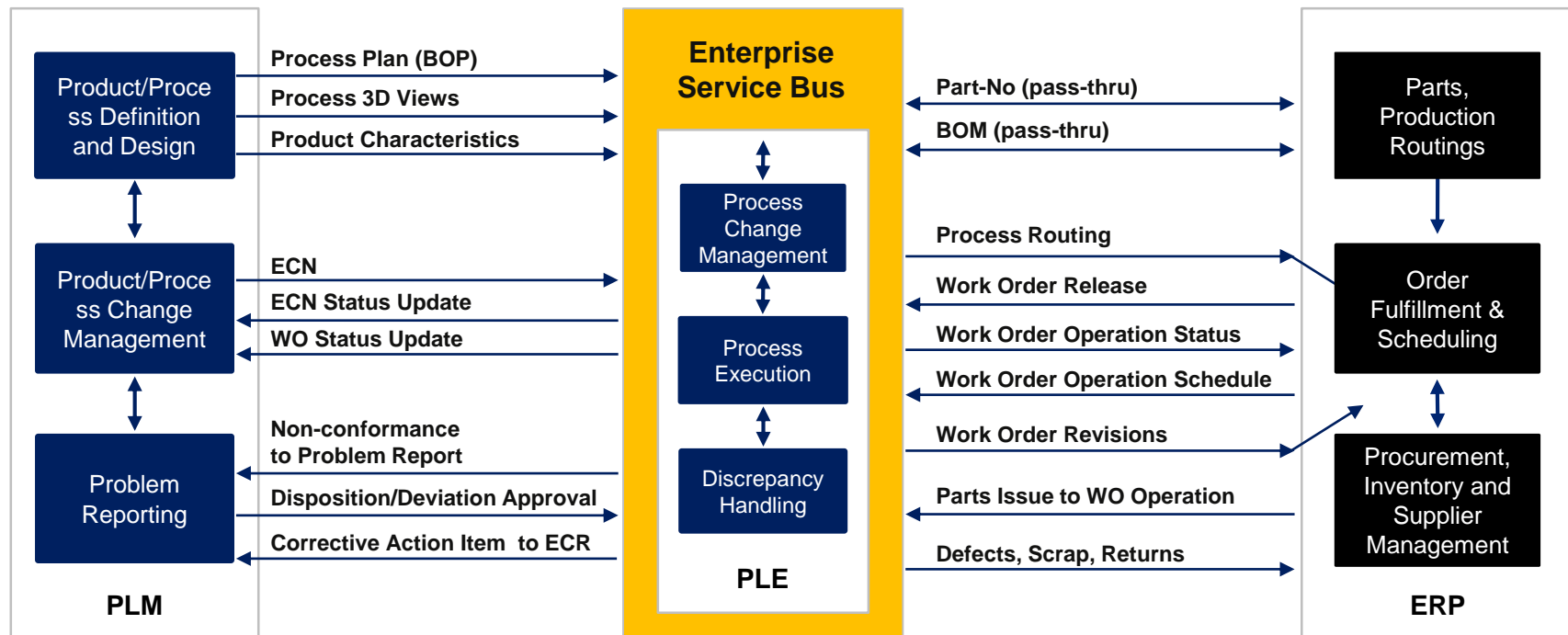
- Process Specific Visuals are Time-Consuming to Create and keep current. They are usually:
 - Sketches
 - Photos
 - Model-Based Views
 - Multi-Page PowerPoint or Word Docs
- They become obsolete almost as soon as they are birthed...
- Using Model-Based tools to auto-create process Visuals saves time and eliminates errors. They require process steps with assigned components. The PLE provides a framework for creating these process recipes in order to generate Model-Based Visuals automatically for new processes and Modified Processes after ECOs.

The PLM – PLE – ERP Integration Bridge



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The PLE Integration Bridge offers Standard Interfaces to PLM and ERP to facilitate growing and sustaining the Digital Thread





THANK YOU

QUESTIONS?