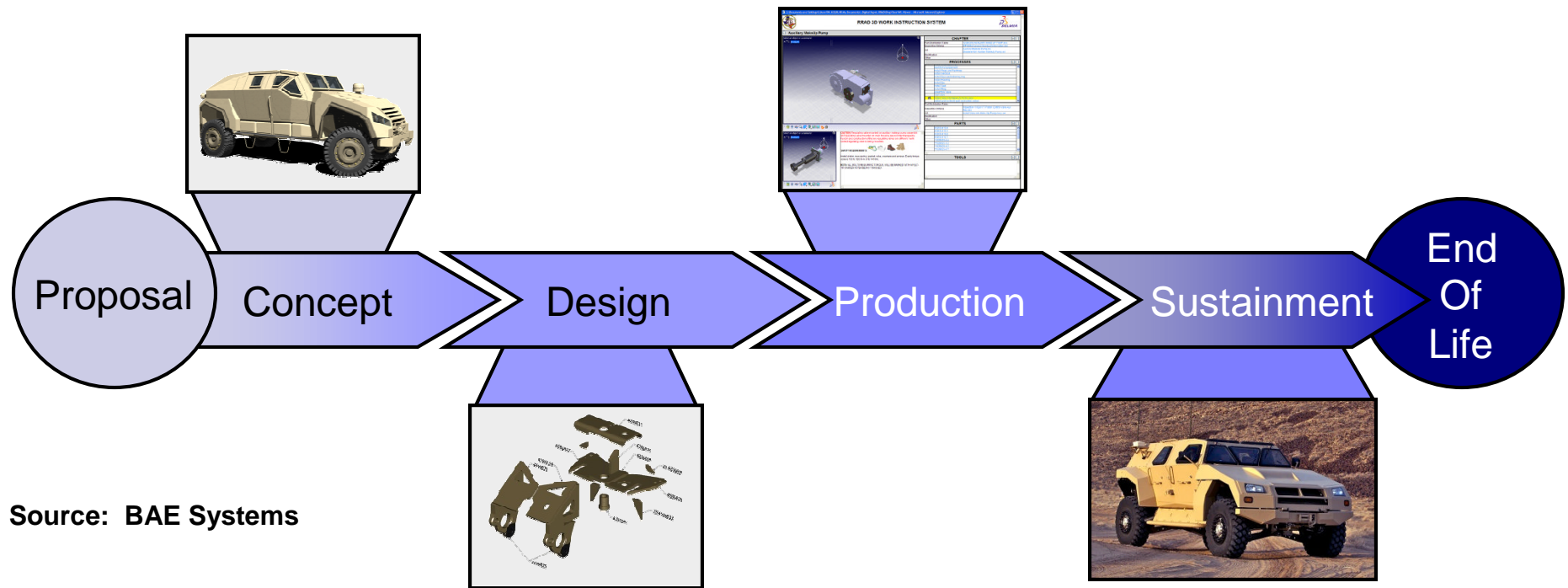


Model Based Enterprise: Implementing MBD

Simon Frechette

National Institute of Standards and Technology

Model Based Enterprise



- MBD Product Model is master
- All product data is contained in model structure – PMI, annotations, material, etc.
- Maximum data reuse
- Direct use of data in downstream applications – substantially reducing lead times
- Full product lifecycle support
- Revision control through PDM system



What is an MBD Model?

- The product data model is a collection of 3D objects, associated product information, and configuration control information that forms a complete, integrated representation of the product.
- The central concept embodied in model-based definition (MBD) is that the 3D product model is vehicle for delivery of all the detailed product information necessary for all aspects of the product life cycle.
- Any number of views of the model can be composed, detailed, and annotated for specific downstream operations including cost analysis, produceability, process planning, assembly simulation, procurement, manufacturing, quality assurance, and standards compliance.

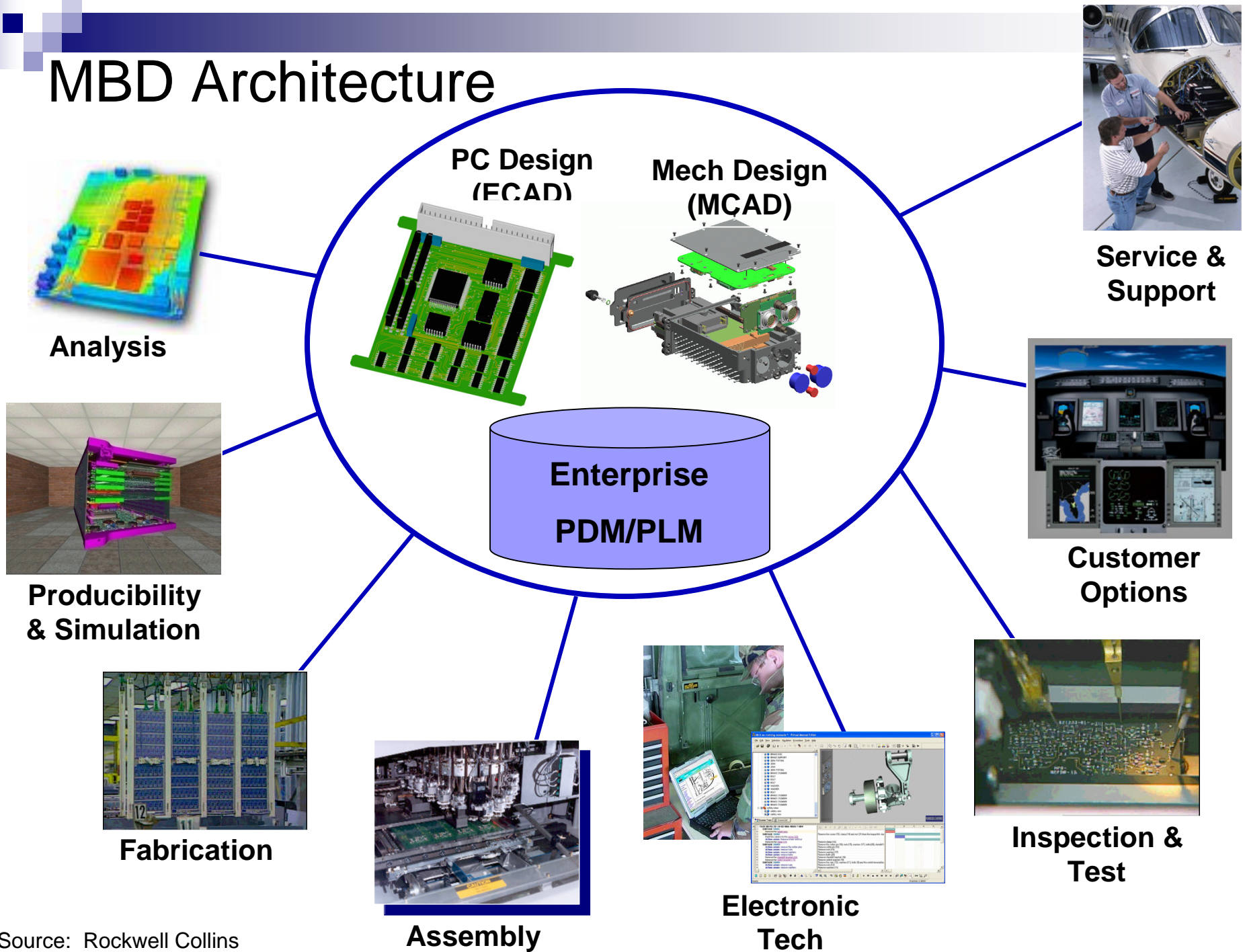


3D MBD Advantages

Reported by an Aberdeen Group study:

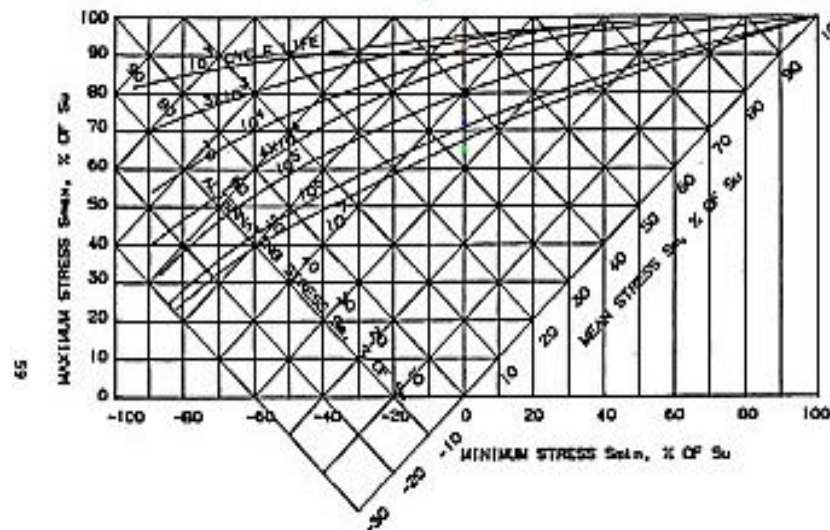
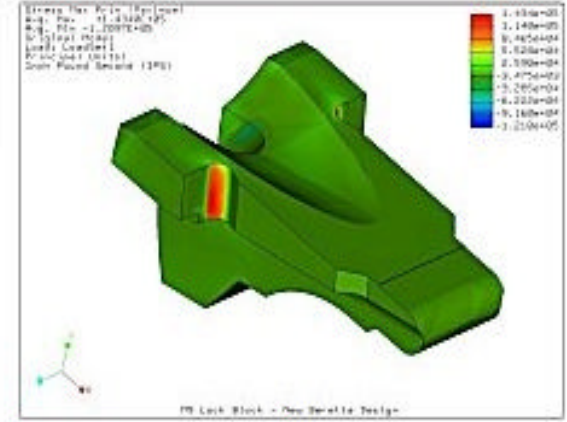
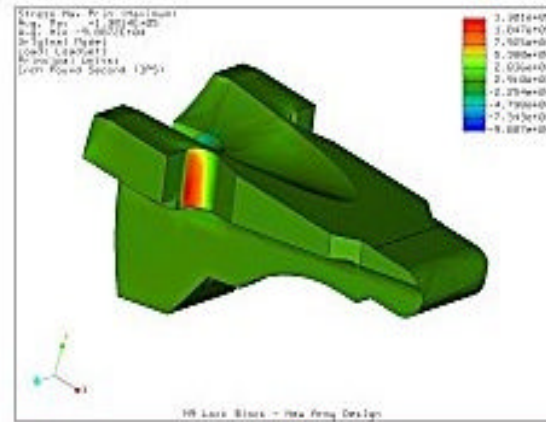
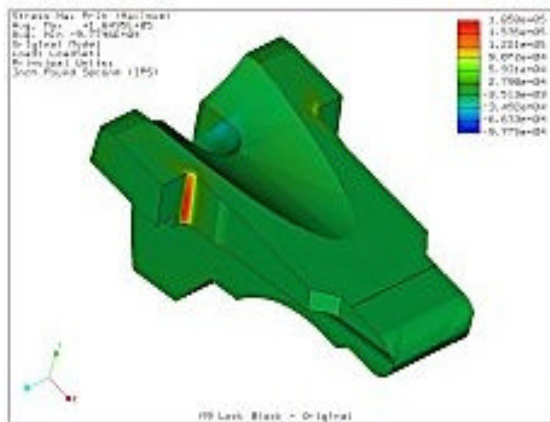
- When manufacturers use 3D models, they build only half the prototypes
- 3D tools reduce the development cycle by 30-50%
- Standard parts libraries provide significant reduction in component assembly time
- 3D model use reduces non-conformance by 30-40%
- 30-40% of non-conformances are due to 2D drawing inaccuracies
- 85% of companies still use 2D drawings for some applications

MBD Architecture



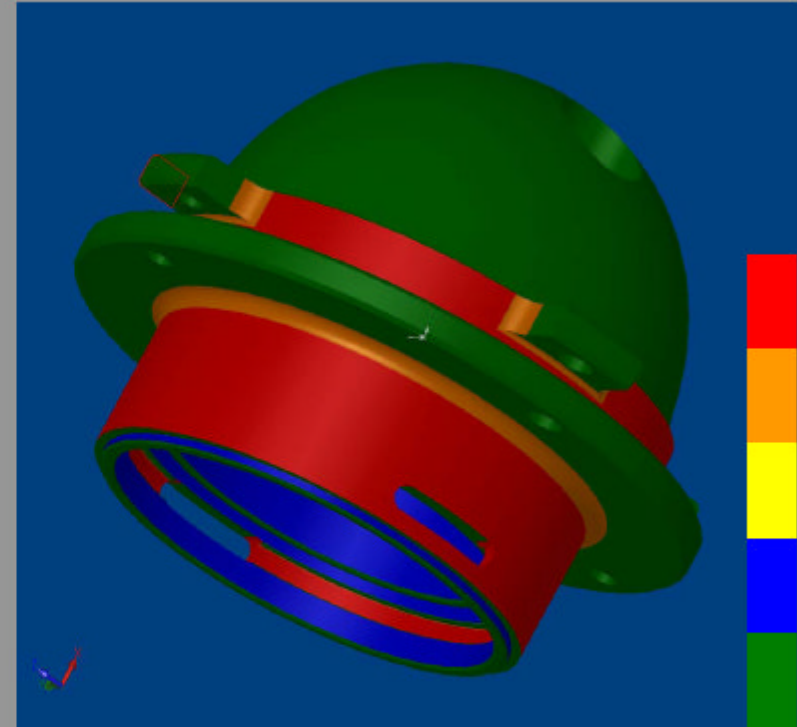
Source: Rockwell Collins

Engineering Analysis

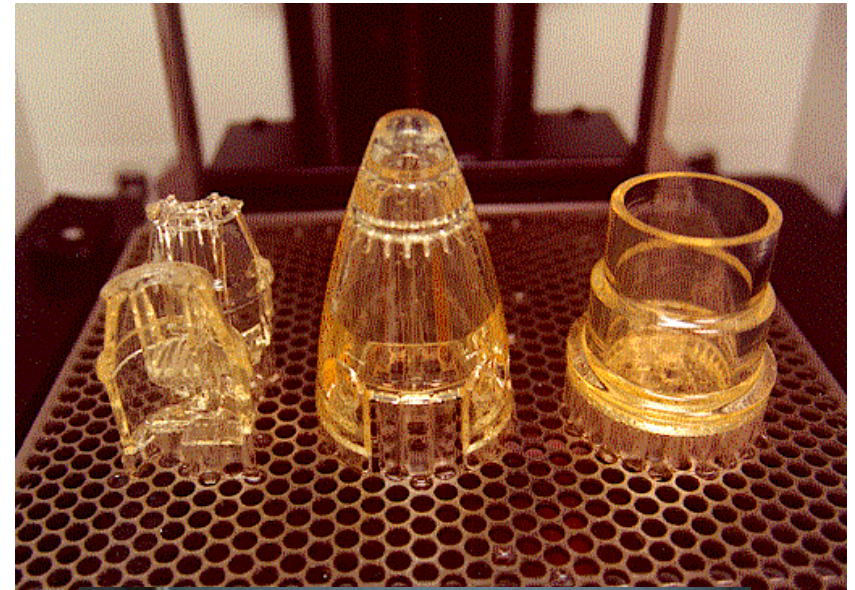
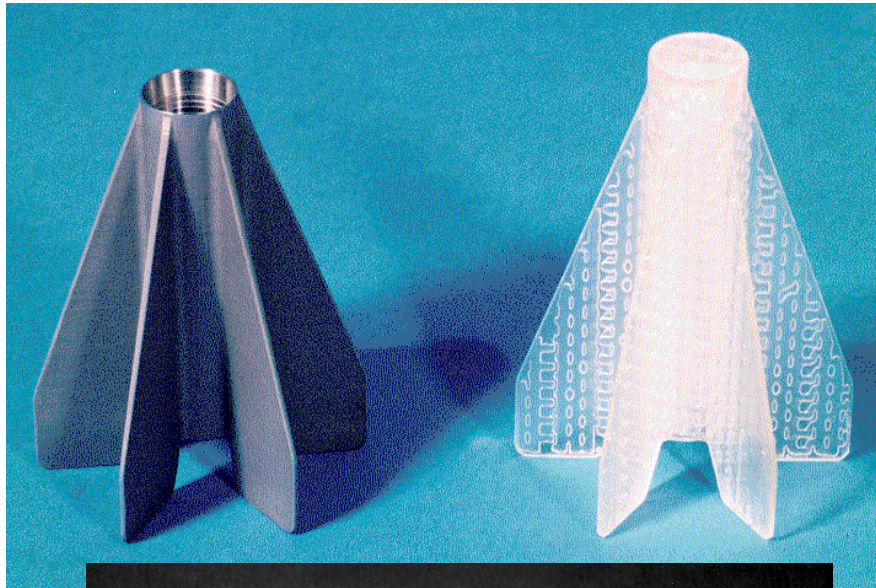


Model Validation

- 87.0 / 100 FBTol score
- 28 issues identified
 - 1 tolerance with incomplete data
 - 18 features not fully located
 - 7 features with no orientation constraints
 - 2 features with no form constraints
- Check result level colors
 - 5 RED TolFeats.
 - 13 ORANGE TolFeats.
 - 0 YELLOW TolFeats.
 - 4 BLUE TolFeats.
 - 49 GREEN TolFeats.

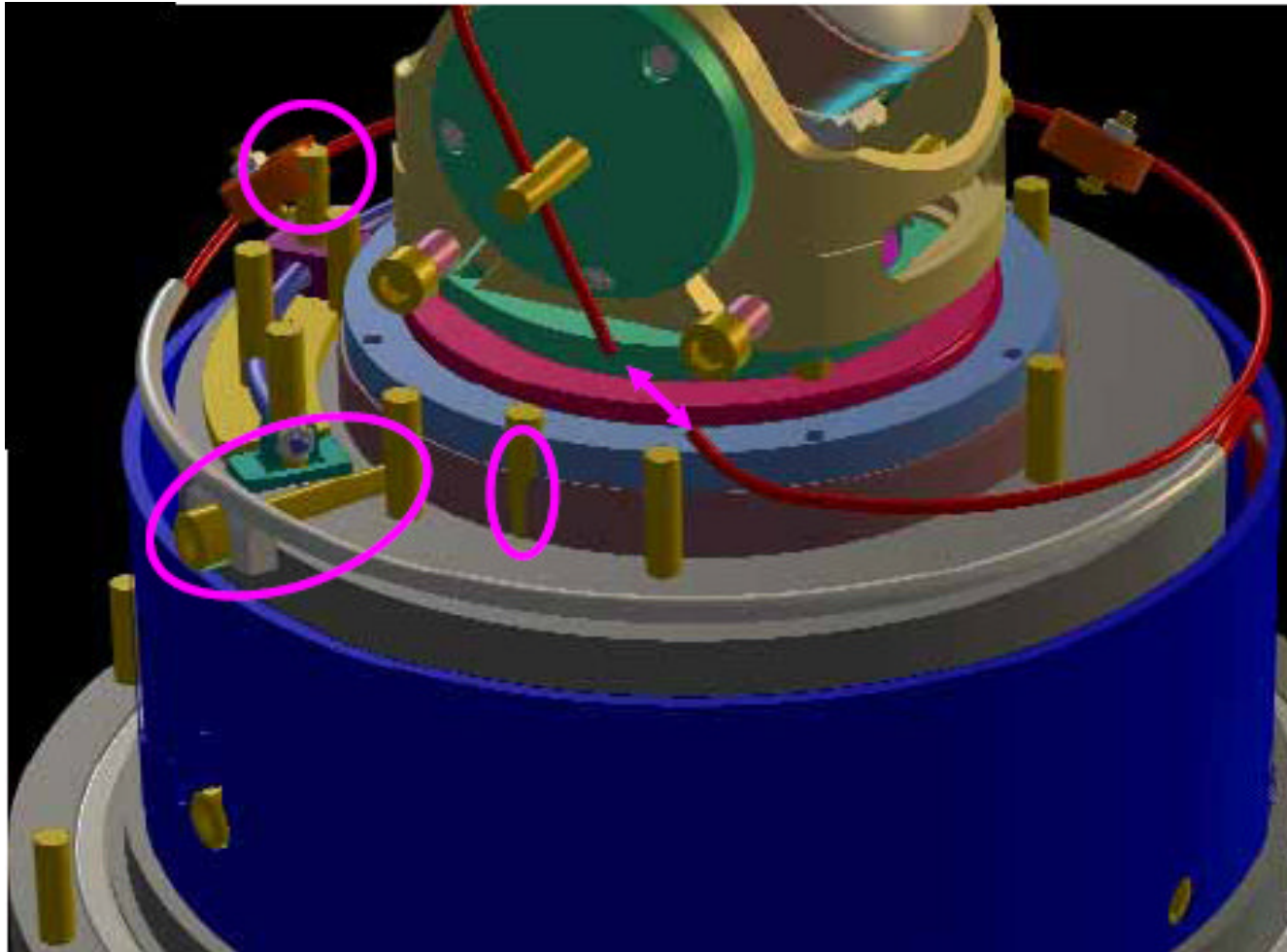


Rapid Prototype

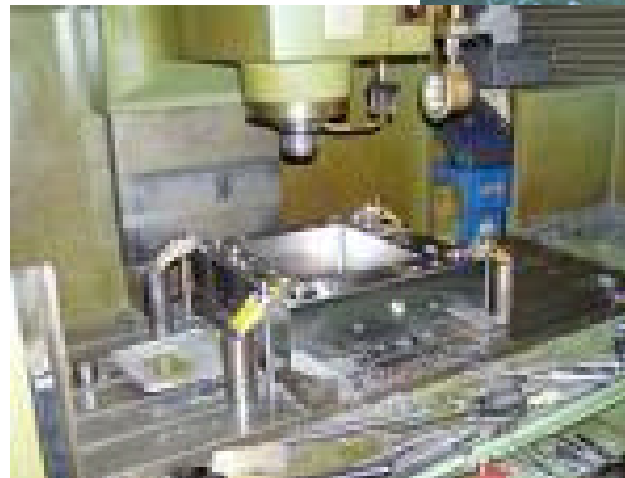
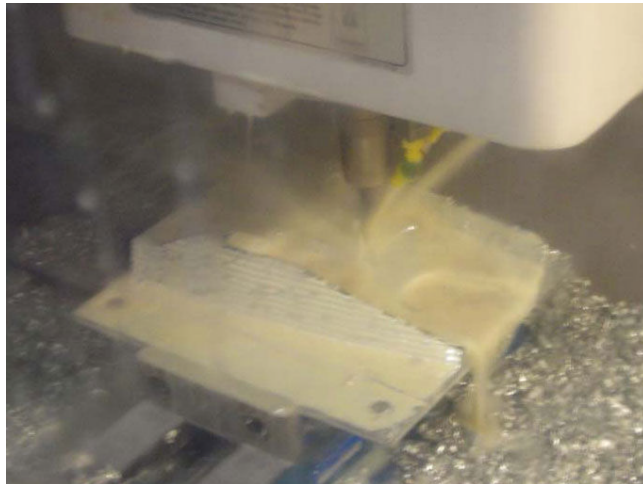
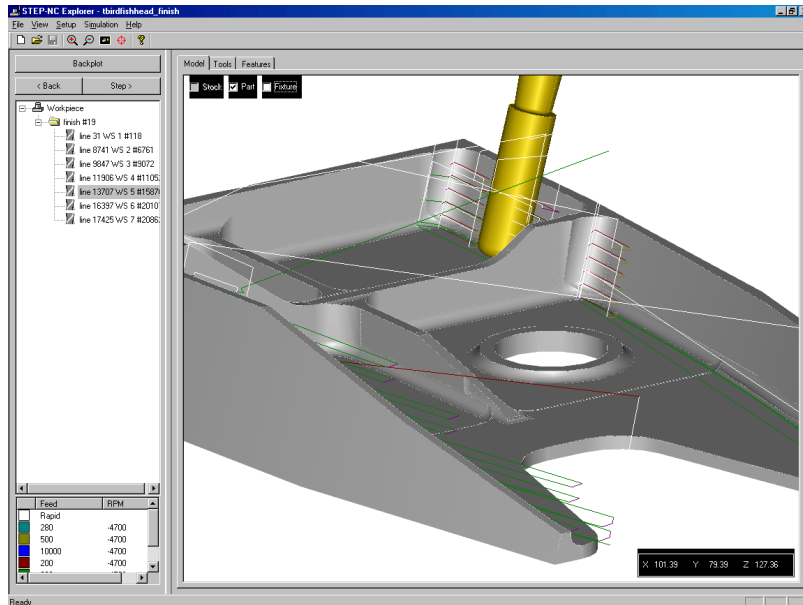


Source: Jeff Windham RIA

Virtual Assembly Validation



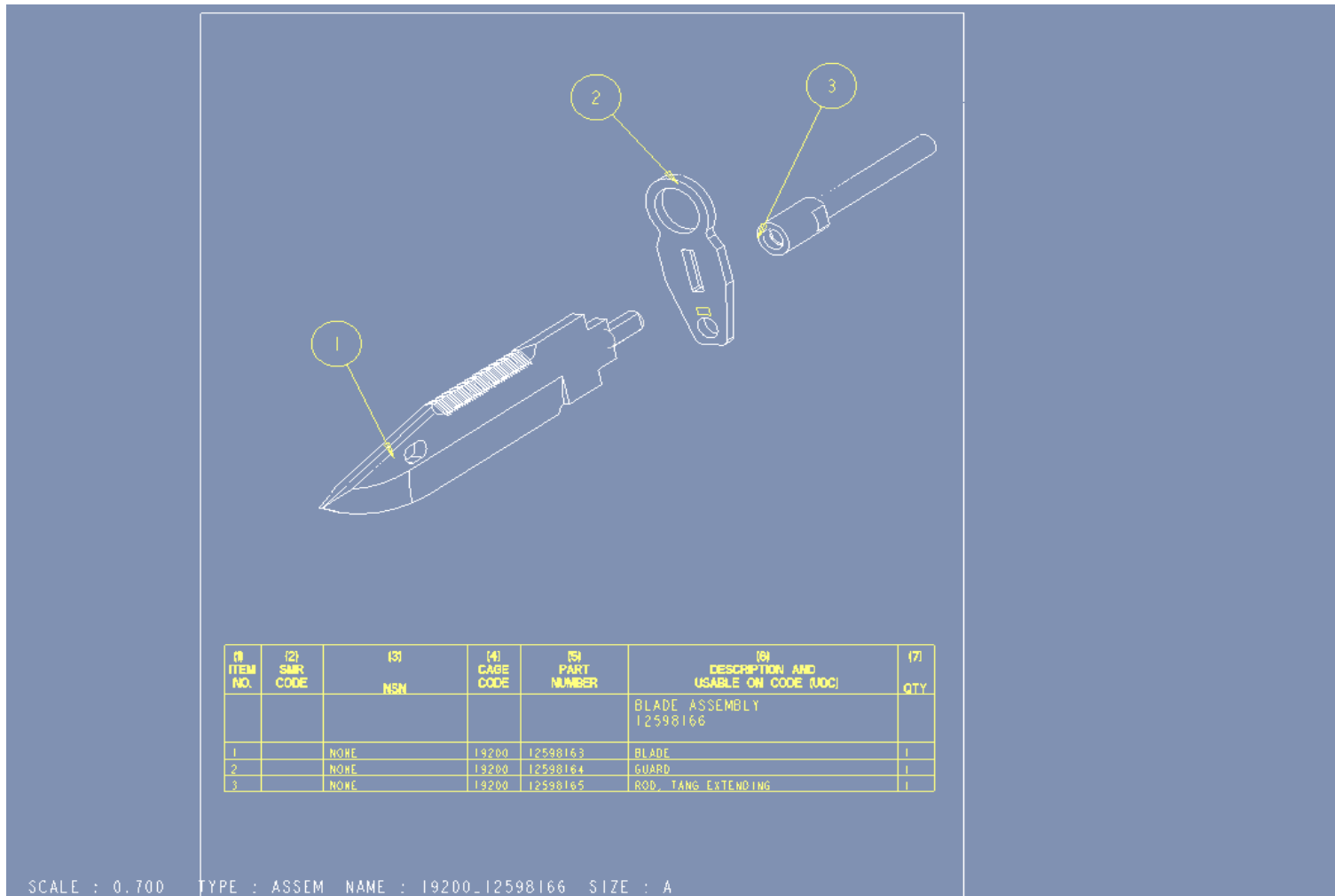
Manufacturing



Source: STEP Tools Inc.

Technical Manuals

3D SOLID MODELS ALLOW AUTOMATED CREATION OF TECHNICAL MANUAL PAGES

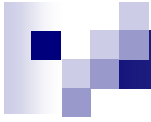


Source: Jeff Windham RIA



Advantages of MBD

- Faster design revisions
- Build and test components and assemblies in a virtual environment (do-overs are no problem)
- Infinite viewpoints and exploded views of assemblies
- Direct to rapid prototyping
- Direct to engineering analysis (stress, thermal, interference fit, tolerance stack-up, etc.)
- Reduced manufacturing lead time and cost
- Automated generation and update of drawings (when drawings are needed)
- Generation of technical manuals directly from model data
- Costing, materials acquisition, marketing, training...
everyone benefits!



MBD reduces cost and lead times, but also presents some significant challenges.



MBD Issues

- MBD data is digital – many advantages, but having only digital data presents several significant issues
 - Proprietary application file formats limit choices
 - Suppliers need data format for low-cost manufacturing applications and viewers
 - Digital data storage and long term access – no paper drawings
 - Products often outlive software applications & and computer hardware used to create them



MBD Issues

- Validation of 3D model as product master
 - Transition from drawing based release process to digital only, 3D MBD based release process
 - 3D model quality
- Application vendor lock-in
 - Proprietary data formats inhibit use of best-in-class applications and tools
 - Open standards not implemented by all vendors
- Supply chain data exchange
 - Dissemination of model based data to supply chain
 - Access to model based data by small suppliers



MBD Issues

- Technical data package requirements
 - Delivery of model based data to customer
 - Specification of 3D data delivery requirements
problem for DoD – what data? What format?
- Long term access to digital data
 - Product life cycles are increasing dramatically (90 year life for B52?)
 - Digital data storage
 - Application revisions cause interpretation errors even in the near term (3-5 year time frame). Difficult to detect.
 - Long term data format standards still in development



MBD Data Access Scenarios

■ Use

- Design, analysis, production, training, maintenance

■ Reference

- Preserve information in its original state
- 3D visualization
- Application certification (view of data is unchanged)

■ Reuse

- Allow for future modification
- Input to re-engineering, analysis, or manufacturing

■ Rationale (what were they thinking?)

- Encode construction history, design intent, lifecycle management information, etc.



Technical Data Packages for Suppliers

- Most OEMS moving away from TDPs with digital models and hard copy drawings to digital-only and 3D models only
- TDPs can contain redundant formats
 - Native
 - Proprietary, yet affordable viewer formats
 - Standard formats such as STEP
 - Use what you can



Technical Data Packages for Customers

- DoD working to revise TDP specifications for MDB
 - Data format requirements
 - Level of data
- What data should the government purchase?
 - Operate, maintain, repair, upgrade
 - Technical manuals
 - Product data – enough to produce spare parts?
 - Manufacturing process and tooling data?



Data Longevity

At least three technology life cycles must be considered:

Product

The products defined by
the design data

(50+ yrs)

Storage

The technologies used to store &
retrieve the digital data

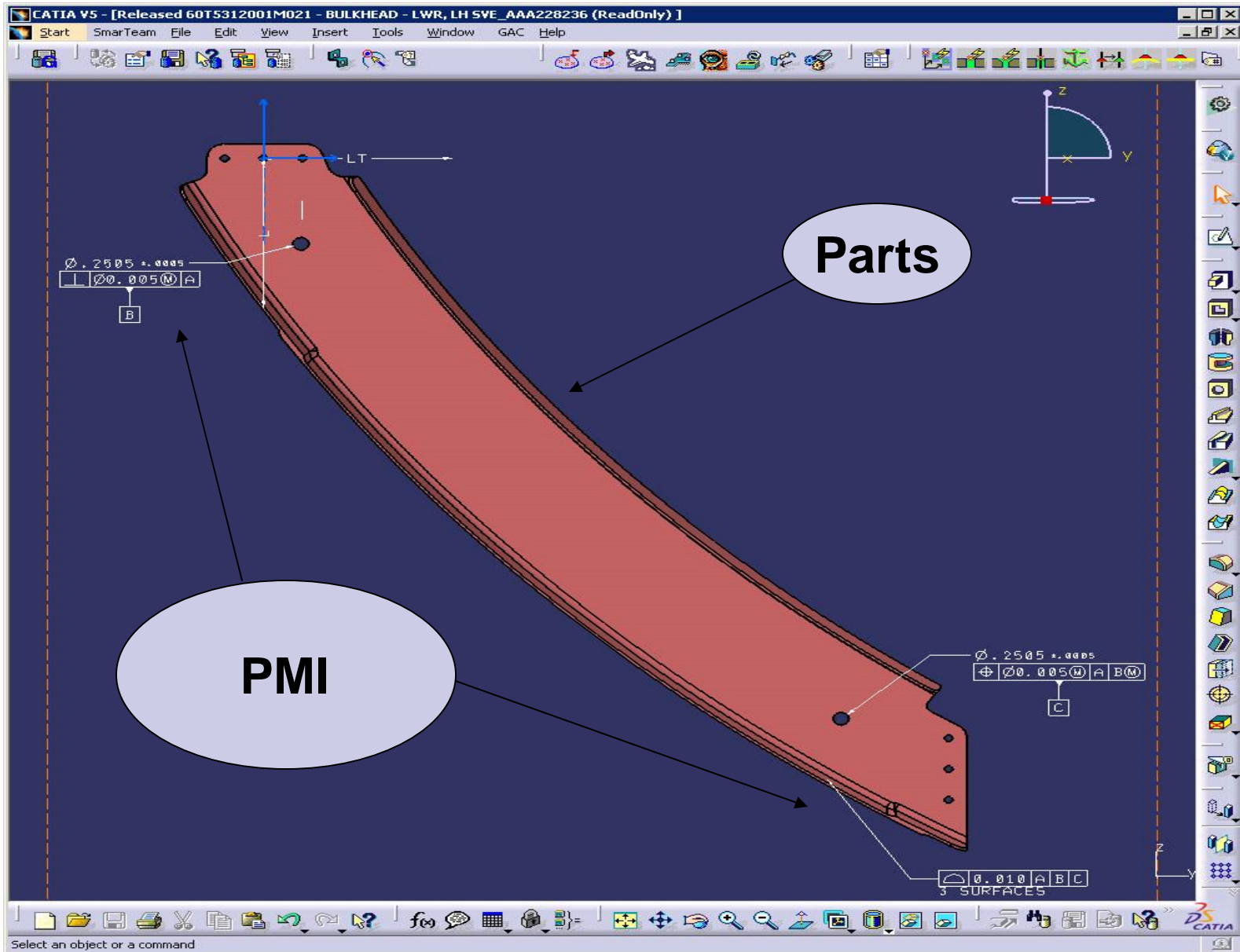
(~10 yrs)

Applications

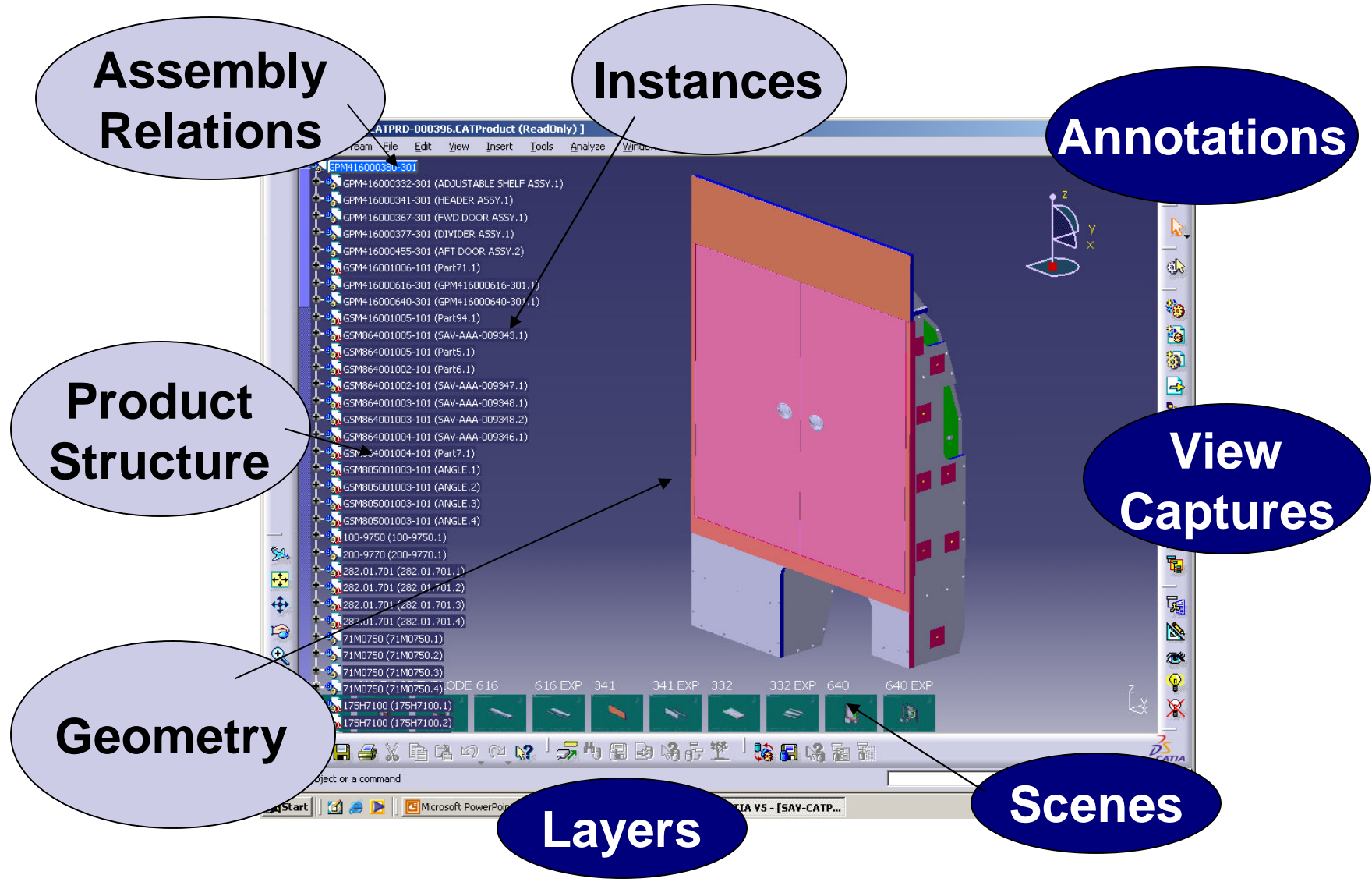
The technologies used to interpret
the data

(~3 yrs)

What Data to Persist?



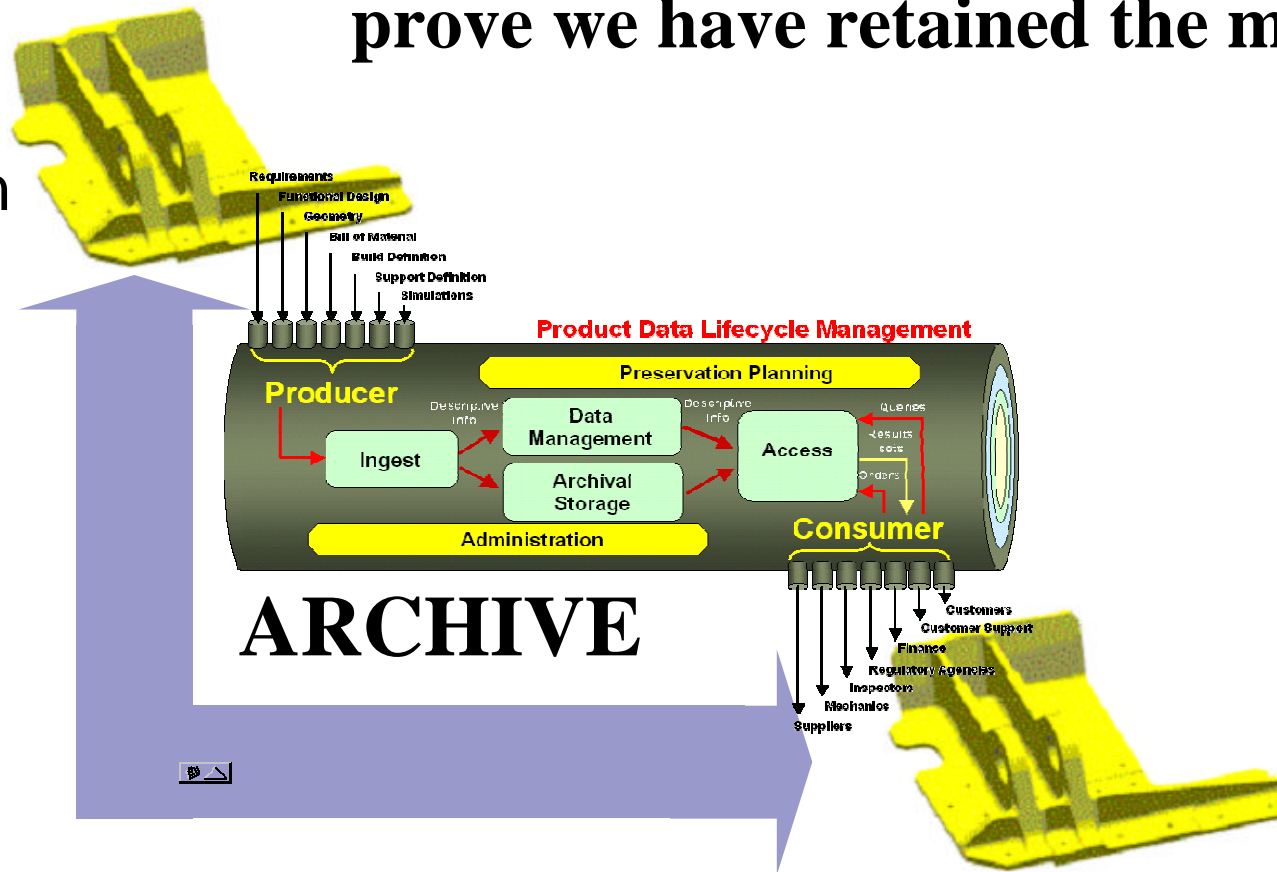
What Data to Persist?



Model Verification

For model as master, we need to prove we have retained the master

What
Went In

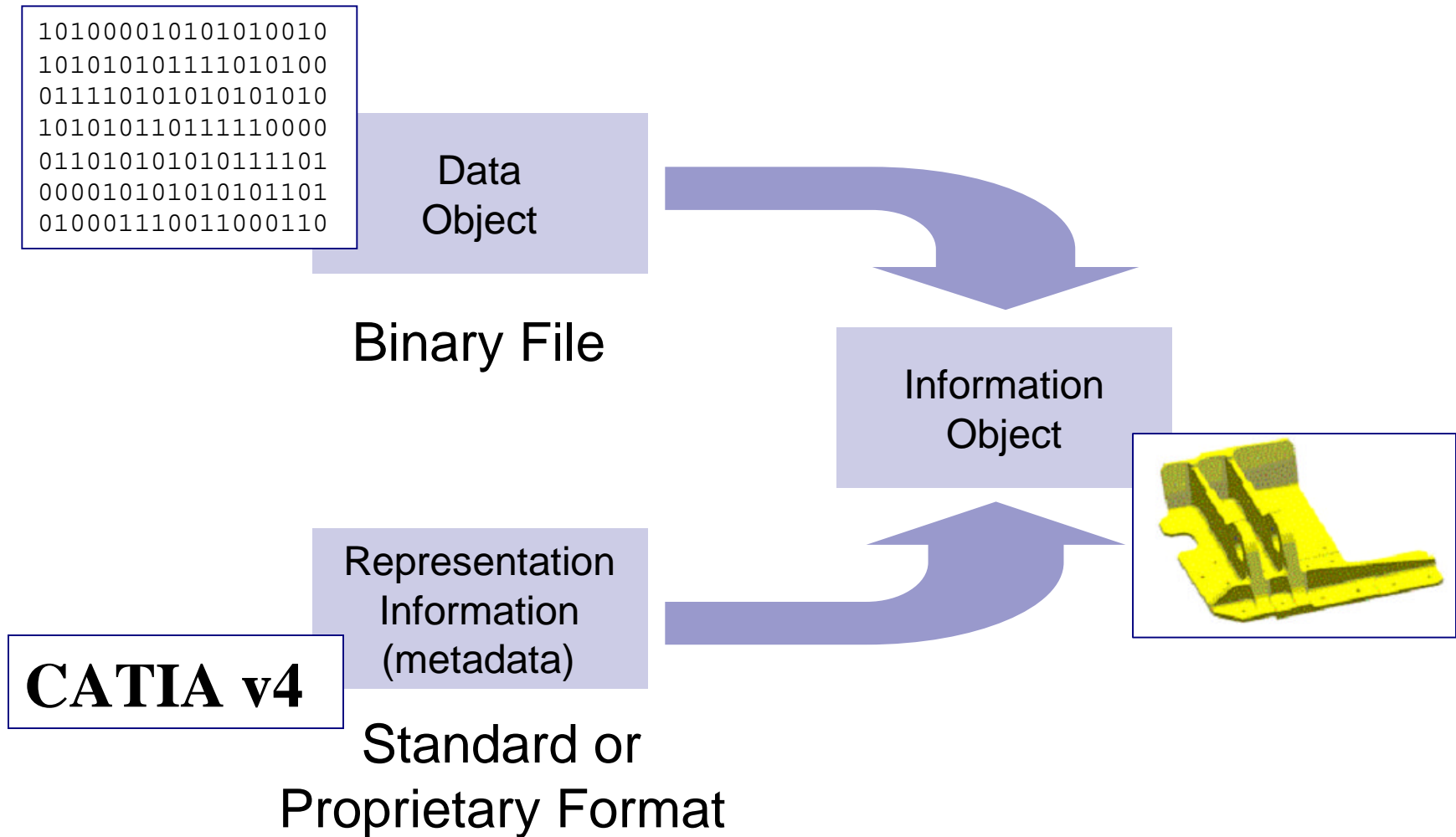


Is What
Came
Out

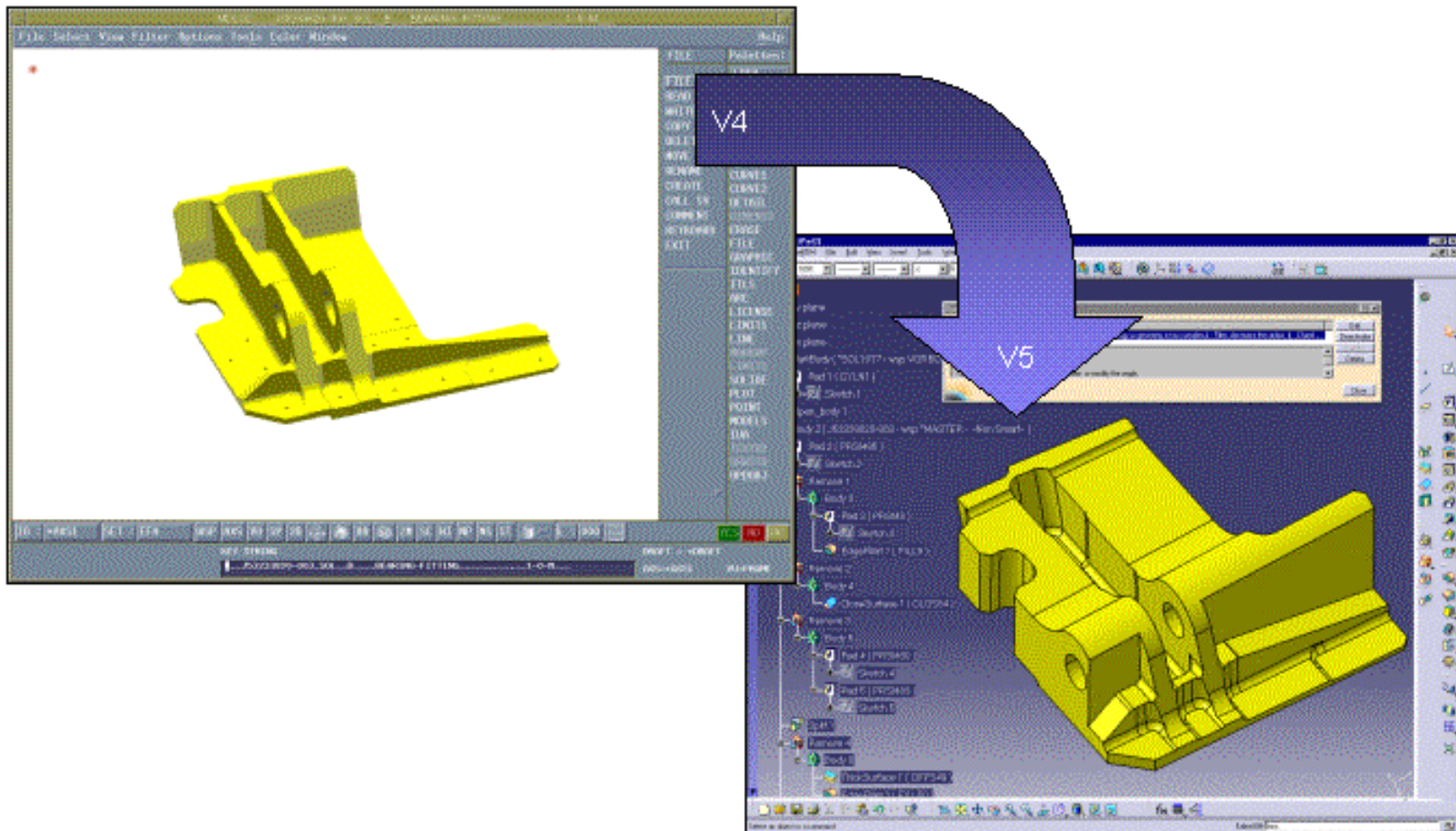


Approved and released MBE data is subject to changes in data interpretation from multiple generations of applications and applications revisions

Information = Data + Interpretation



Effects of Generation Change

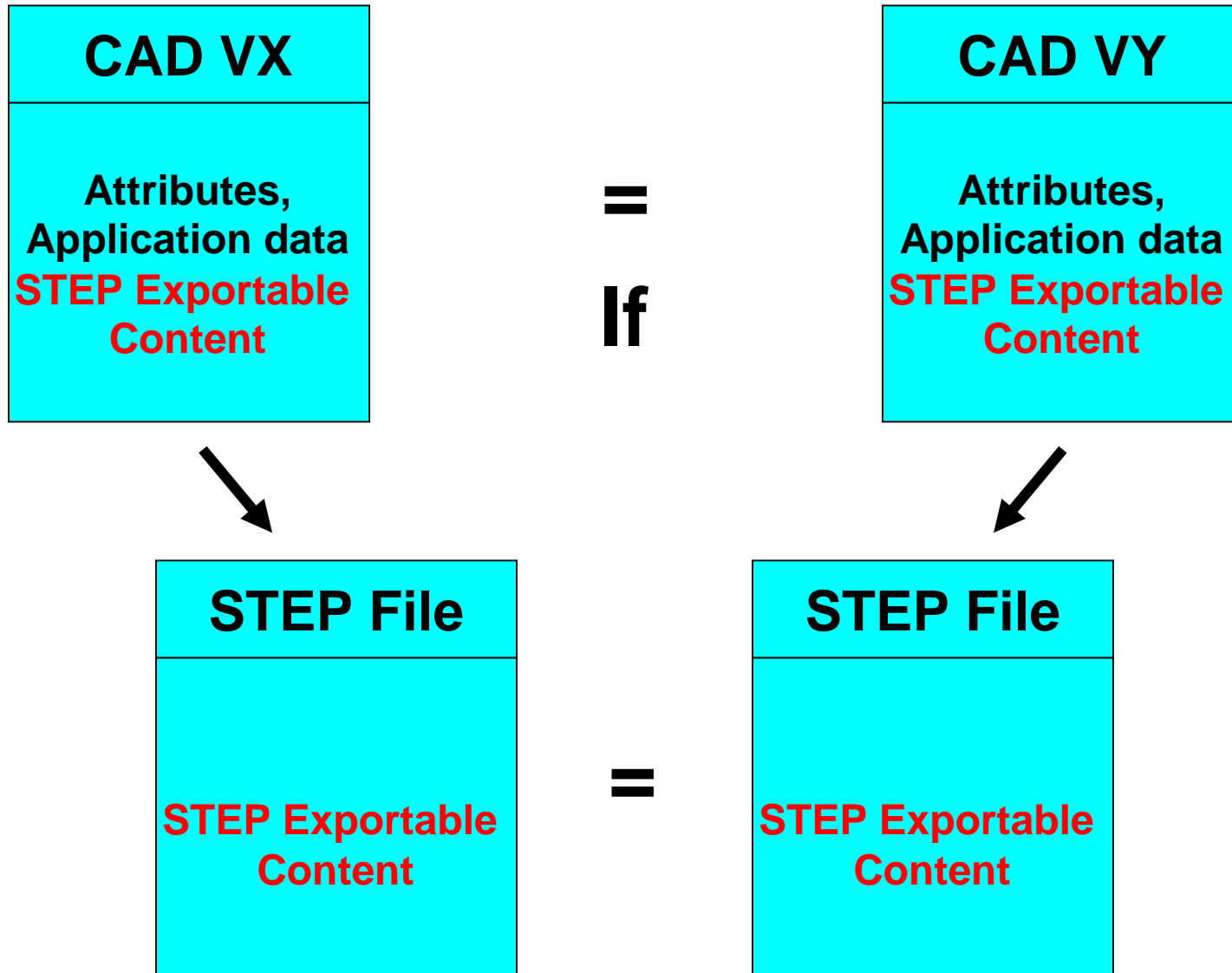




CAD Application Evolution

- The current version of the application is only the first technology in a series of technologies to be used to view the data for the life of the product.
- The Certification Content will have to be migrated through multiple generations of technologies over the life of the system
- The Certification Content will have to be validated for consistency each time the data is moved to a new application or technology. (transfer of the application of ownership and the attribute of approval)

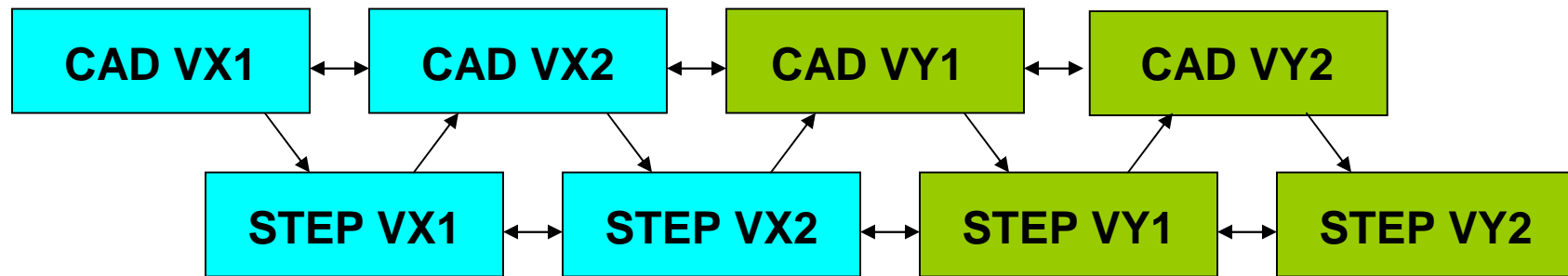
CAD Application Revision Validation



Application Validation Using Standards

Technology X
7-15 years

Technology Y
next 7-15 years





NIST Activities Supporting MBD

- Standards development and testing
 - STEP standards
- Model validation methods and metrics
- Participation in industry consortiums
- Working with DoD on TDP and MBD data format specifications
- Funding research activities through the NIST grants program
 - STEP PMI

STEP PMI Implementation Pilot

The screenshot displays the Pro/ENGINEER Wildfire 4.0 software interface. The main window shows a 3D model of a mechanical part with several PMI annotations. The annotations include dimensions and tolerances such as $\phi 37.44^{+0.01}_{-0.01}$, $.250_A$, $3.00^{+0.01}_{-0.01}$, $.200_{A, B, C}$, and $.050$. The left-hand side shows a tree view with the following structure:

- FISH2_W_ANNO22.PRT
 - FISH2_W_ANNO22
 - Import Feature id 4
 - Annotation 1
 - A_1
 - A
 - B
 - C
 - AE_DRIVEN_DIM0
 - AE_DRIVEN_DIM1
 - AE_DRIVEN_DIM2
 - AE_SET_DATUM_TAG_A
 - AE_SET_DATUM_TAG_B
 - AE_SET_DATUM_TAG_C
 - AE_GTOL0
 - AE_GTOL1
 - AE_GTOL2
 - AE_GTOL3

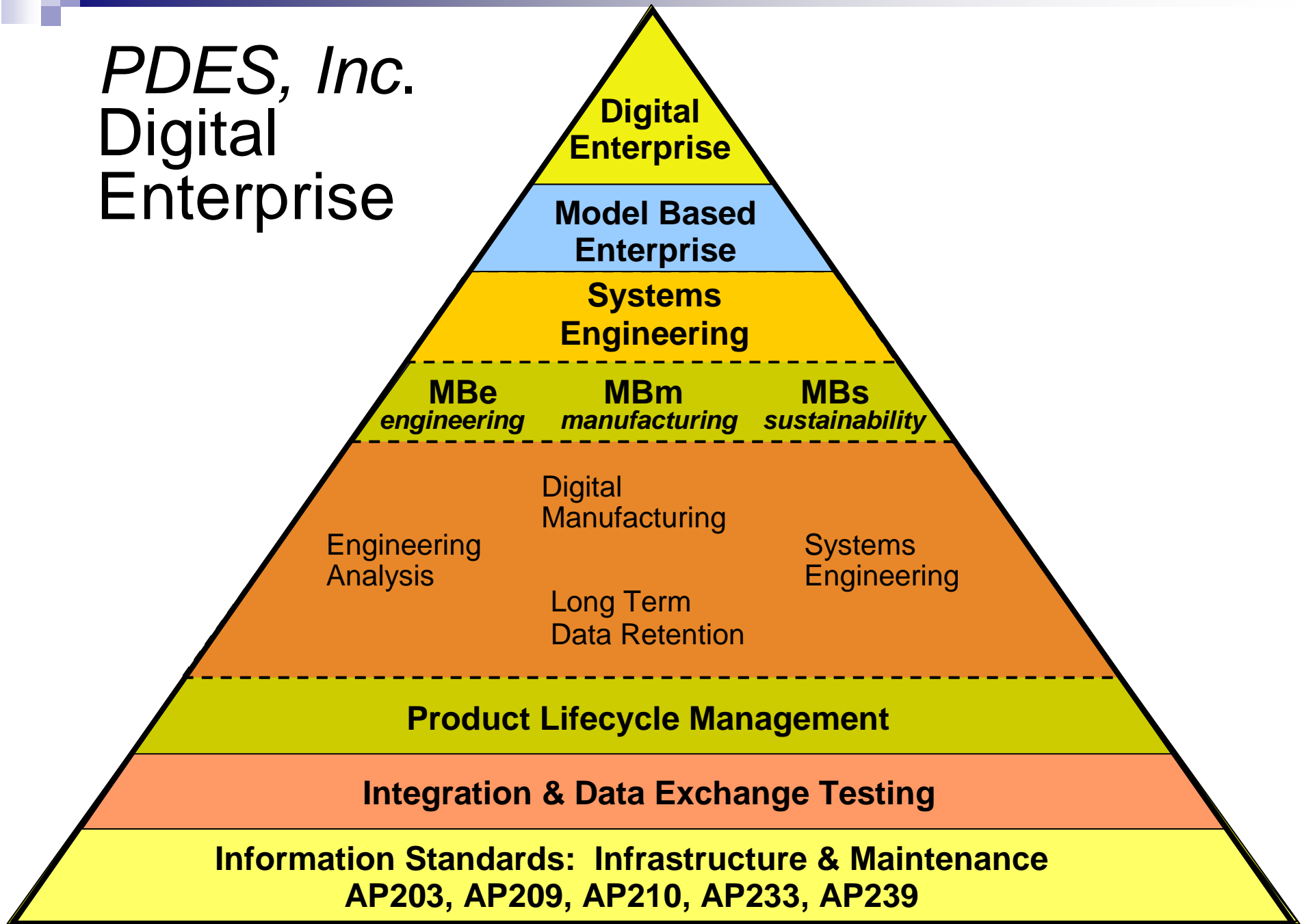
The bottom window, titled "INFORMATION WINDOW (fish2_w_anno22.log)", displays the following text:

```
Preprocessor Version: PRO/ENGINEER BY PARAMETRIC TECHNOLOGY CORPORATION, 2008090
Originating System: PRO/ENGINEER BY PARAMETRIC TECHNOLOGY CORPORATION, 2008090
Authorization:
File Schema: AP203_CONFIGURATION_CONTROLLED_3D_DESIGN_OF_MECHANICAL_PARTS_AND_ASSEMBLIES_MIM_LF
```

ADVANCED_BREP_SHAPE_REPRESENTATION	1
ADVANCED_FACE	115
ANNOTATION_CURVE_OCCURRENCE	19
ANNOTATION_OCCURRENCE	39
ANNOTATION_PLANE	4
ANNOTATION_SYMBOL_OCCURRENCE	14

The information window also includes a "Smart" dropdown menu at the bottom right.

PDES, Inc.
Digital
Enterprise





Summary

- MBD reduces cost and lead times, but also presents some significant challenges
- NIST is working with industry and government agencies to address these challenges
- Model validation, supply chain, and long term data access are issues where new policies and standards must be developed