

# 3D Collaboration & Interoperability '08

May 15-16, 2008 - Denver, Colorado

## 3D CAD Model Validation

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# Presentation Outline

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## □ Context

- Introductions
- Business
- Engineering

## □ Validation Overview

- Examples
- Quality and confidence
- Technologies

## □ Validation Applications

- Migration
- Design
- Release
- Change
- Archival

## □ Future Directions

# Introductions

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## ❑ ITI TranscenData

- Private, debt-free, profitable U.S. company since 1983
- Interoperability solutions business in International TechneGroup Inc.
- “Transcend above your data problems”
- ...or “Smooth interoperability is a transcendental experience”

## ❑ Presenter

- Mechanical engineering education
- CAD model quality consulting (12+ years)
- Father of CADIQ product (“CAD Interoperability Quality”)
- Global perspective as a youth and a professional

# Business Context

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## ❑ Global Competition

- Time to market
- Narrow profit margins
- Rapid innovation

## ❑ Global Corporations

- Industry consolidation
- Engineering out-sourcing
- Multi-national supplier base

## ❑ Government Regulation

- Quality control
- Certification
- Traceability
- Environmental control

# Engineering Context

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## ❑ Complex Systems

- Multi-disciplinary integration (MCAD + ECAD + ...)
- Multi-disciplinary optimization (CAD + CAE + CAM + PDM + ...)
- Multi-system environment (CATIA + NX + Pro/E + ...)
- Extreme reliability (air, space, battlefield, medicine ...)

## ❑ Model-Based Engineering and Manufacturing

- 3D model is the master
- Minimal drawing data
- Model used directly in downstream applications

## ❑ Long-term Retention

- 10, 50, 100 years ... “life of the state”
- Document recovery
- Model reuse
- Hardware and software obsolescence

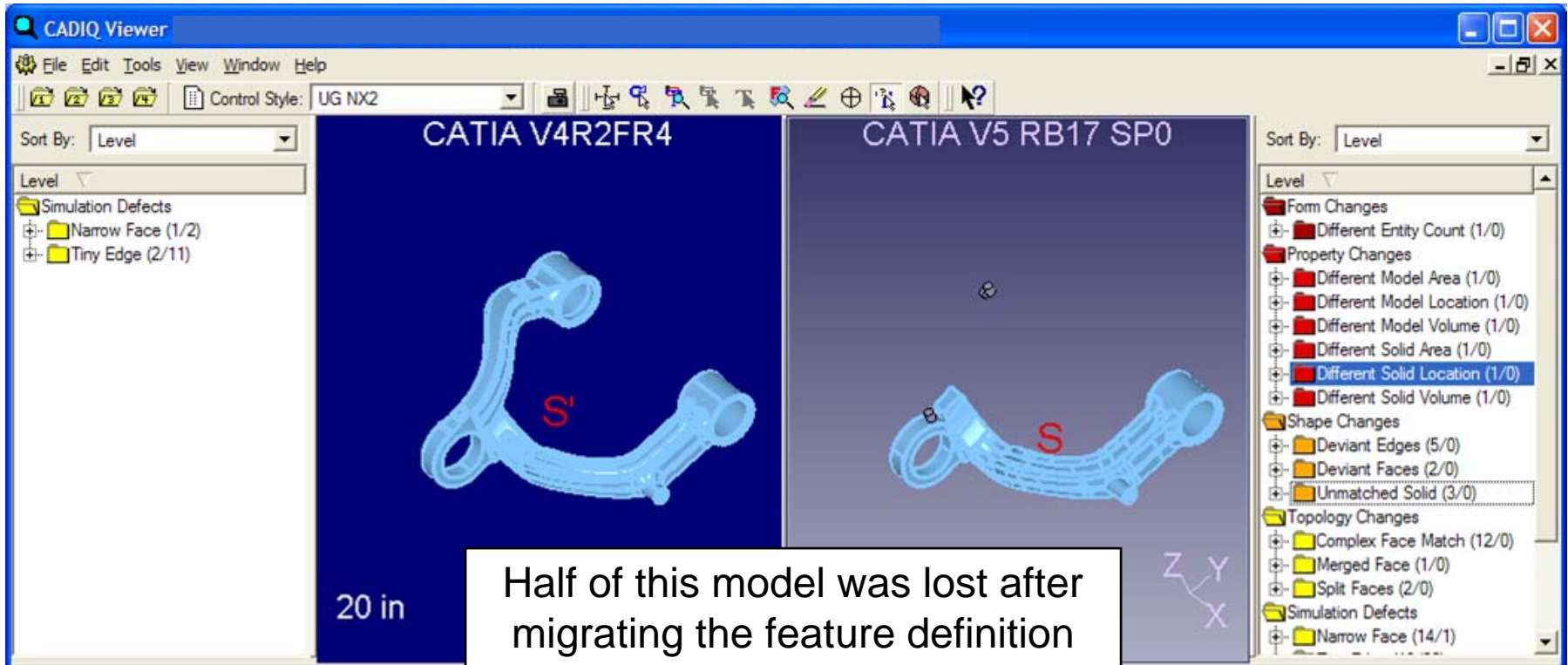
# Legacy Migration Validation



CAD A



CAD B



The screenshot shows the CADIQ Viewer interface with two side-by-side views of a mechanical part. The left view is labeled 'CATIA V4R2FR4' and shows a complete blue mesh model with a red 'S' on its surface. The right view is labeled 'CATIA V5 RB17 SP0' and shows the same model but with a significant portion missing, leaving a skeletal structure. A text box at the bottom of the screenshot reads: 'Half of this model was lost after migrating the feature definition'. The software interface includes a menu bar (File, Edit, Tools, View, Window, Help), a toolbar, and two panels on the left and right. The left panel shows 'Simulation Defects' with items like 'Narrow Face (1/2)' and 'Tiny Edge (2/11)'. The right panel shows a detailed list of differences between the two models, including 'Form Changes', 'Property Changes', 'Shape Changes', and 'Topology Changes'. A '20 in' scale bar is visible in the bottom left of the model area.

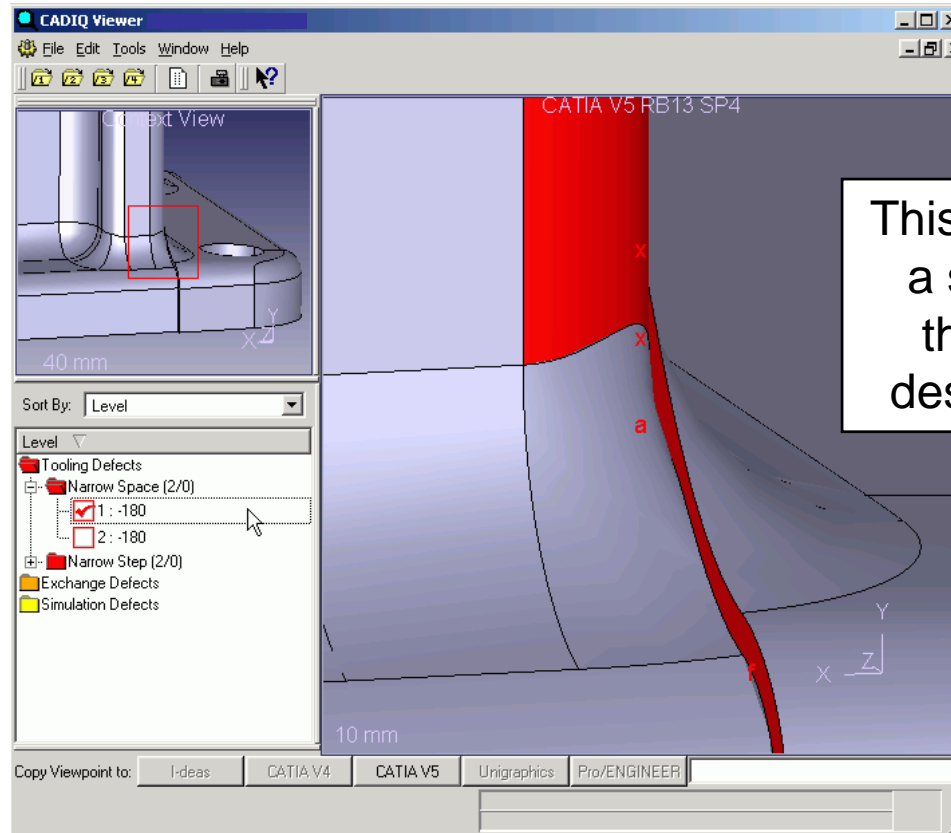
# Design for Manufacturing Validation



CAD

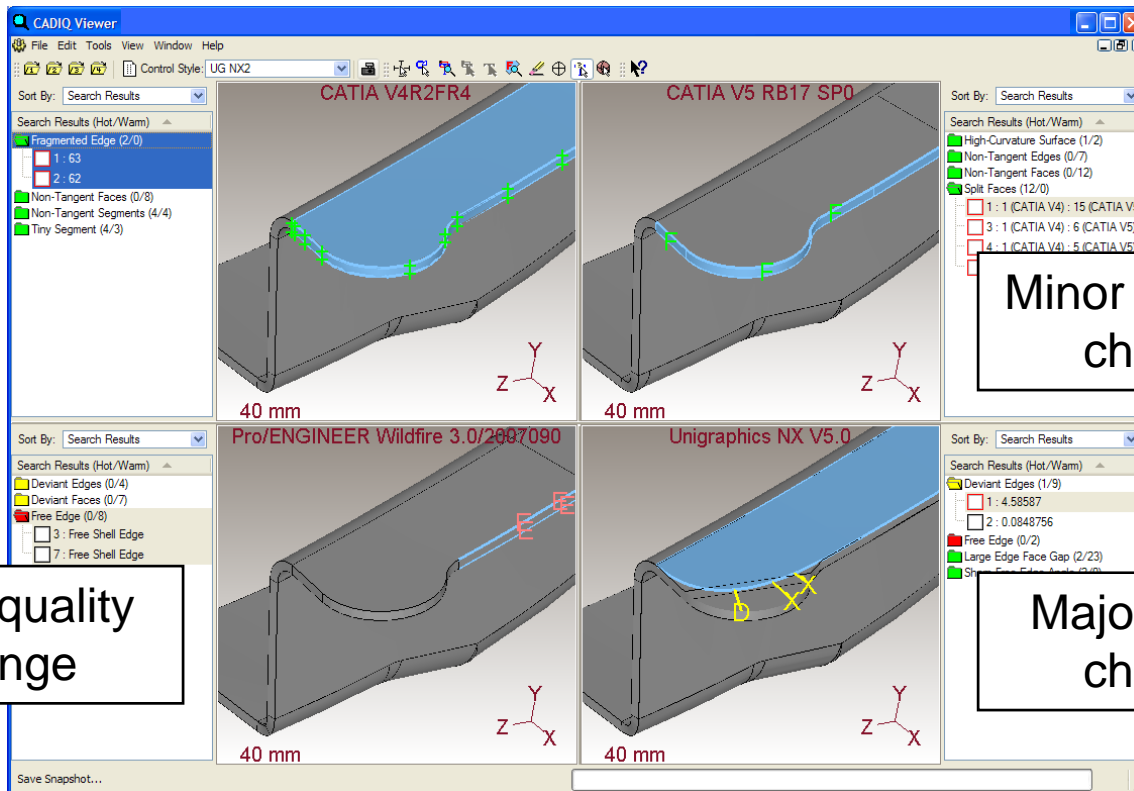
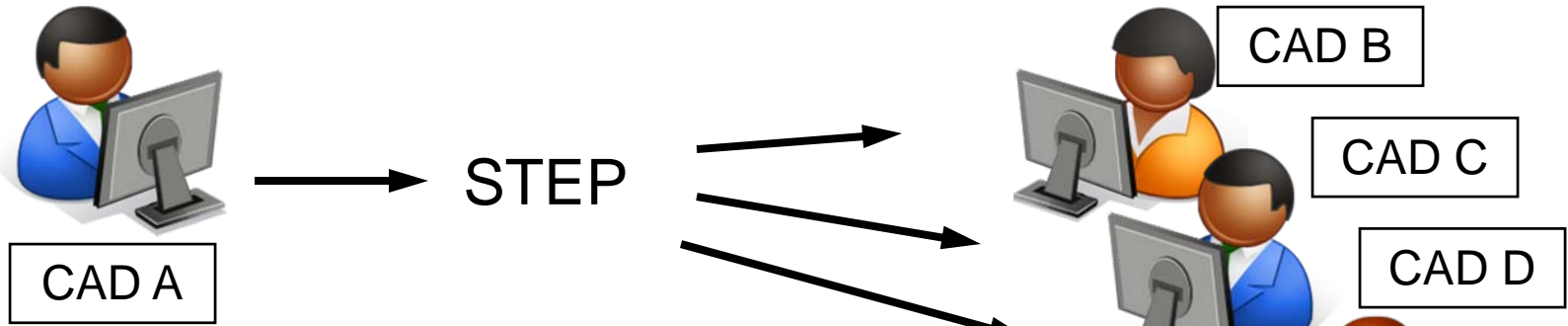


CAE / CAM



This blend has a sharp cut that is not design intent

# Design Release Validation



Minor topology change

Major quality change

Major shape change

# Engineering Change Validation

Rev A



Rev B



?!

CAE / CAM

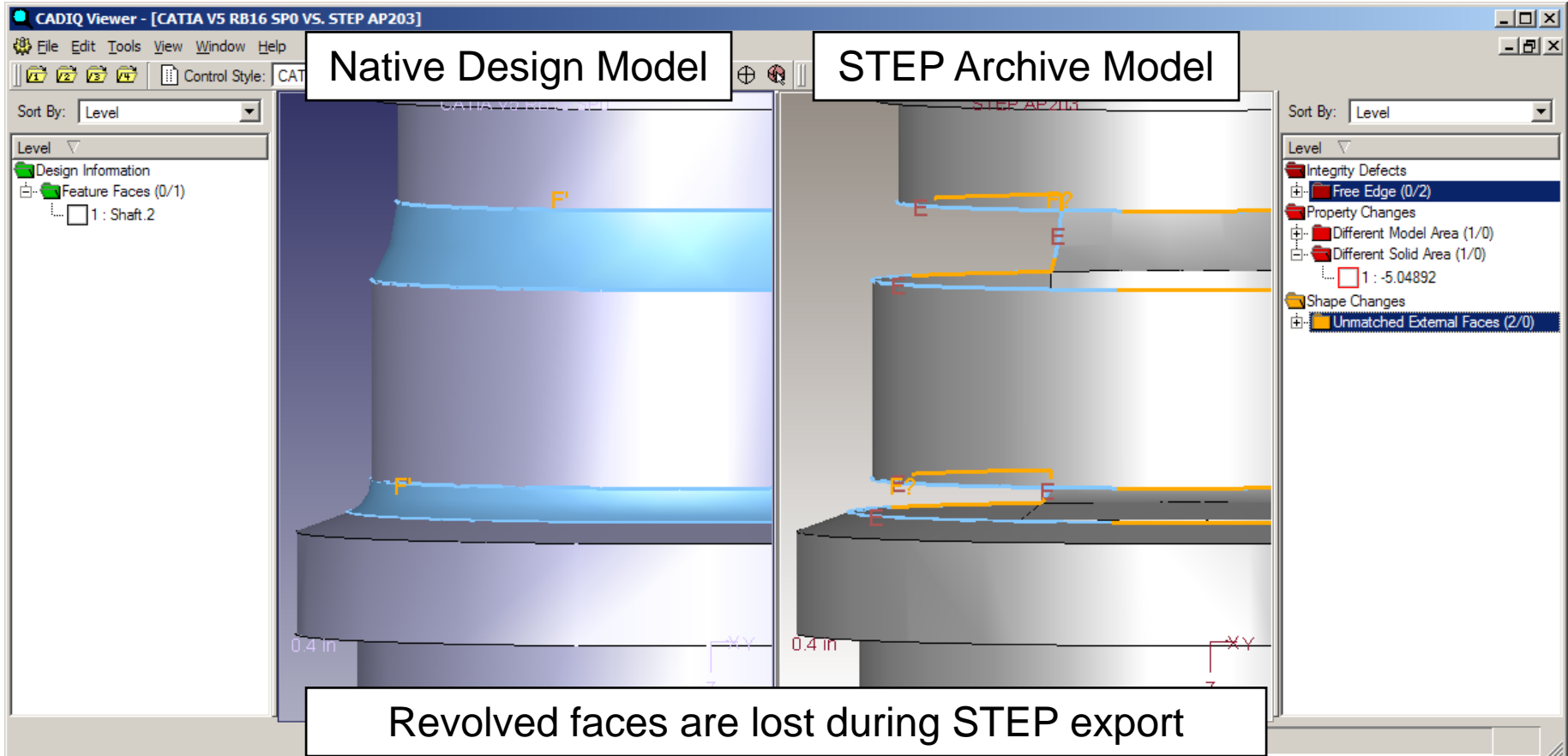
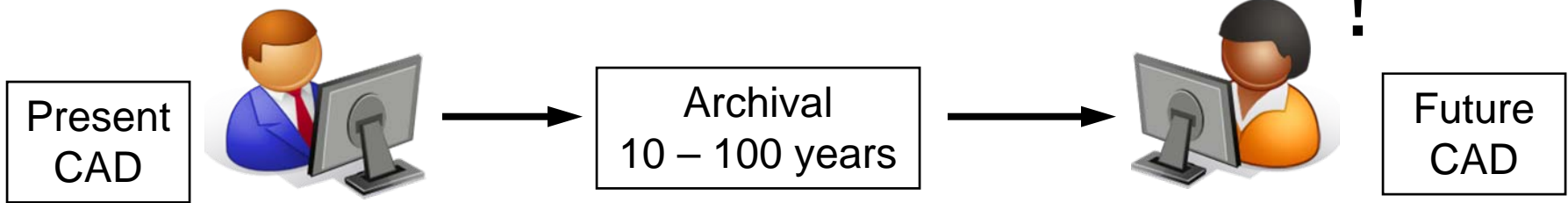
The screenshot shows two side-by-side views of a 3D model in CADIQ Viewer. The left view, labeled 'Released Model', shows a blue part with a bend highlighted in green. The right view, labeled 'Engineering Change', shows the same part with the bend highlighted in yellow and several other features marked with red 'X's. The software interface includes a search results panel on the left and right, and a status bar at the bottom.

**Released Model**

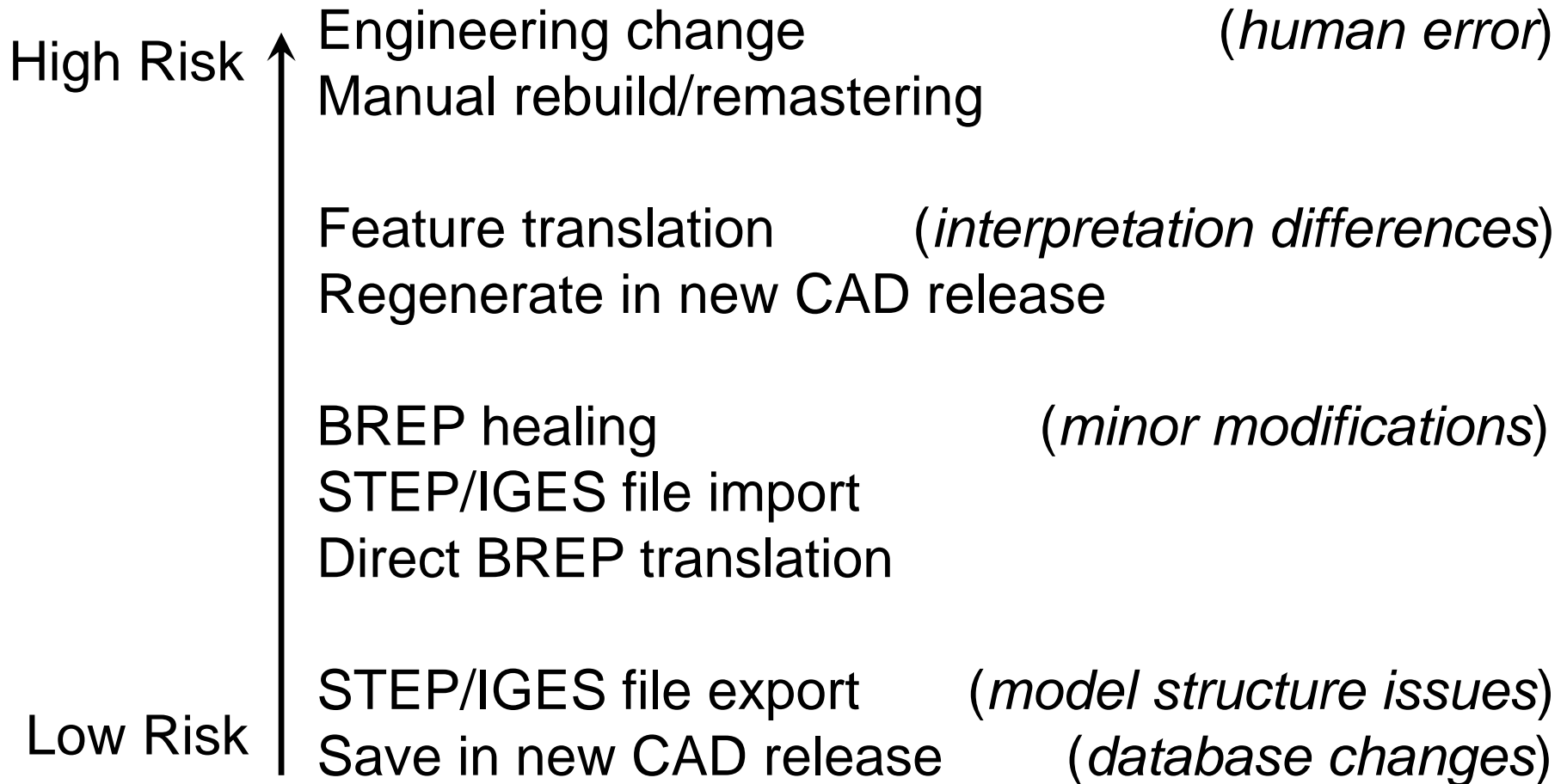
**Engineering Change**

Change to highlighted bend caused unintentional change in location of nearby features

# Long-Term Archival Validation



# Risk of *Unacceptable* Model Changes



# Validation Improves Quality

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## ❑ Early Warning System

- Fix problems before they fester

## ❑ Continuous Quality Improvement

- Defects / opportunities for six sigma metrics
- Justify best practices
- Eliminate worst practices

## ❑ Identify Source of Problem

- Low-quality legacy data
- Legacy modeling techniques
- Worst modeling practices (short cuts)
- Complex 3D modeling obscured by shaded graphics & high-level features—often with unrealistic time pressure
- Revisions by other designers

# Validation Increases Confidence

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- ❑ **Demystify CAD models to improve interoperability**
  - Value of legacy data for design reuse
  - Quality of design data for downstream reuse
- ❑ **Foundation for trust**
  - Quality control between organizations
- ❑ **Monitor dynamic technologies**
  - Hardware improvements
  - Software upgrades
  - System conversions
  - Employee changes
- ❑ **Minimize unknown risk**
  - “What we do not know is most important”

# The Business Challenge of CAD Validation



All too often the organization that needs to spend money on CAD validation is *not* the organization that will benefit from the results.

# Validation Methodology Comparison

## ADVANTAGES

- ❑ **Manual Inspection**
  - Uses existing tools
  - Simple to mandate between organizations
- ❑ **External CAD Application**
  - Simple software architecture
  - Shorter analysis times
- ❑ **Integrated CAD Application**
  - Precise evaluation of native data
  - Correlation with design features
  - Rapid support for new releases
  - Familiar user interface

## DISADVANTAGES

- ❑ **Manual Inspection**
  - Labor intensive
  - Error prone – Incomplete
  - **Mind numbing**
- ❑ **External CAD Application**
  - Data conversion
  - Model evaluation differences
  - Delayed support for new releases
  - Unfamiliar 3D graphics interface
- ❑ **Integrated CAD Application**
  - Complex software architecture
  - Longer analysis times

**CADIQ**<sup>®</sup> is the only multi-CAD integrated validation tool

# Validation Technology Comparison

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## ❑ Two sources of potential differences

- CAD model (data)
- Modeling kernel (evaluators)

## ❑ Two validation tool architectures

- External CAD application
  - Translate is translated before validation
  - External, non-native modeling kernel evaluates the model
- Internal CAD application
  - No modification of native data
  - Internal modeling kernel evaluates the model (same as for creation)

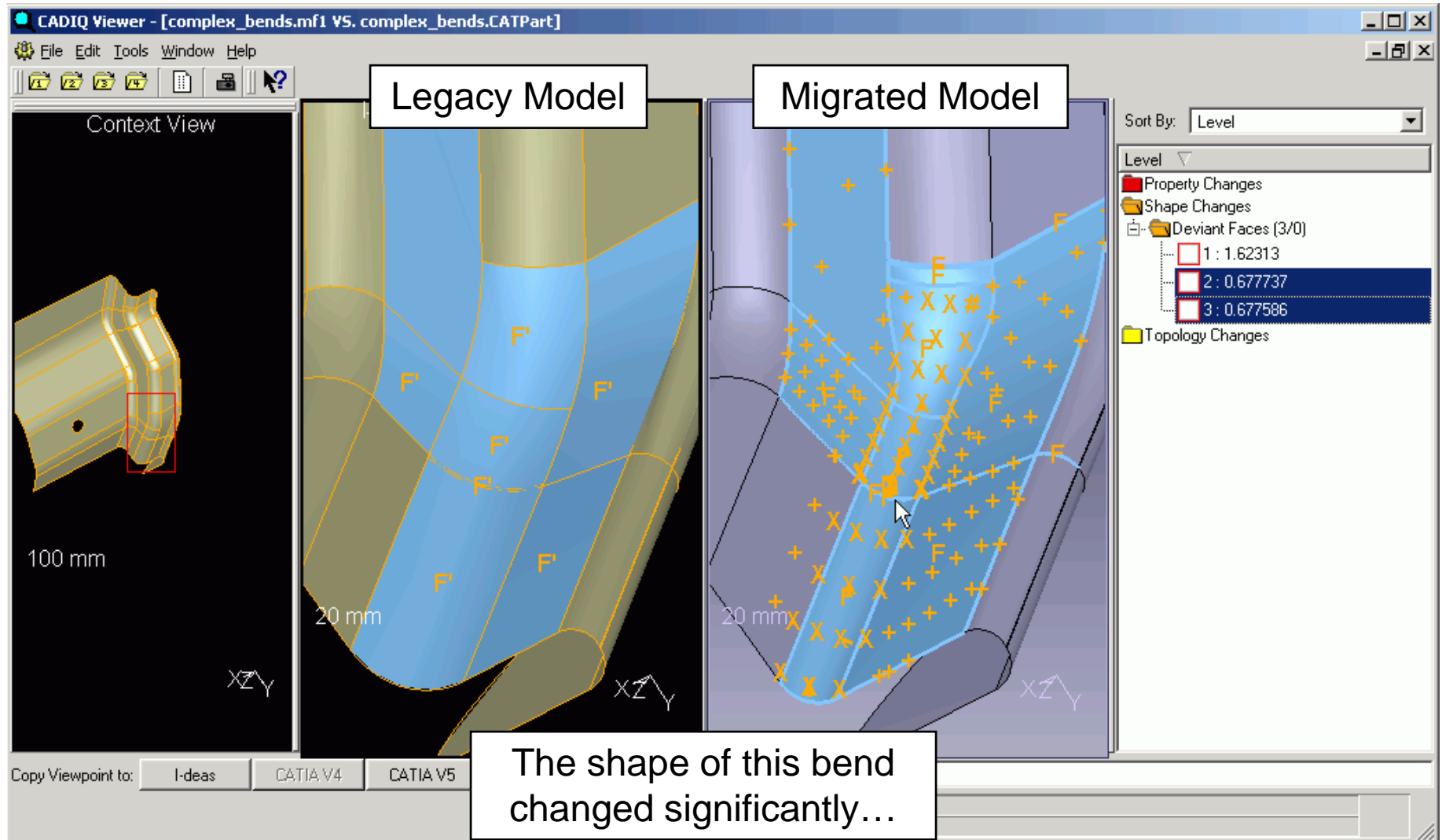
## ❑ Master model validation requirements

- Why risk “false” differences?
- Native modeling kernel changes are critical to discover
  - These undermine the foundation of your master model strategy

# Optimal Model Comparison Strategy

- ❑ **NOT simple “cloud of points” (e.g. tessellation data)**
  - Difficult to balance performance with model coverage
  - Many false changes reported for complex models
  - Difficult to interpret the results
- ❑ **Top-down, PMI-based model comparison**
  - Match high-level geometric entities by type
    - Report lost, added or moved entities
    - Critical for mixed models (solids + surfaces + curves)
  - Match topological faces
    - Splits, merges, rotations, ...
    - Identify which face sets “should” be compared
  - Sample native faces based on type
    - Size, complexity, geometric form, GD&T controls
  - Measure deviations
    - Report unacceptable and “near-miss” deviations
    - Use GD&T controls to intelligently adjust the deviation thresholds

# Legacy Migration Validation (Part 1)



# Legacy Migration Validation (Part 2)

CADIQ Viewer - [complex\_bends.mf1 VS. complex\_bends.CATPart]

File Edit Tools Window Help

Context View

100 mm

Z  
Y X

Legacy Model

Migrated Model

8 mm

8 mm

Z  
Y X

Z  
Y X

Sort By: Level

Level ▾

- Property Changes
- Shape Changes
  - Deviant Faces (3/0)
    - 1: 1.62313
    - 2: 0.677737
    - 3: 0.677586
  - Topology Changes

Copy Viewpoint to: I-deas CATIA V4

...consequently, the location of this datum hole shifted

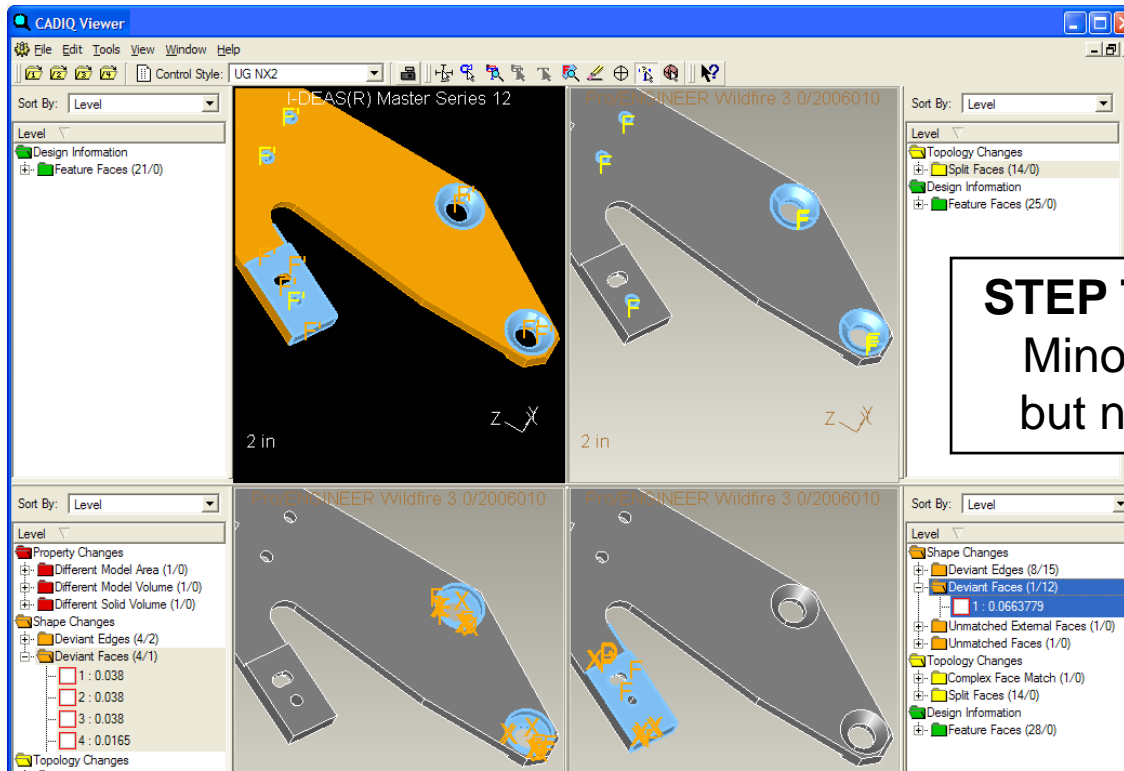
# Legacy Migration Process Evaluation



Which process?

Legacy CAD

Current CAD

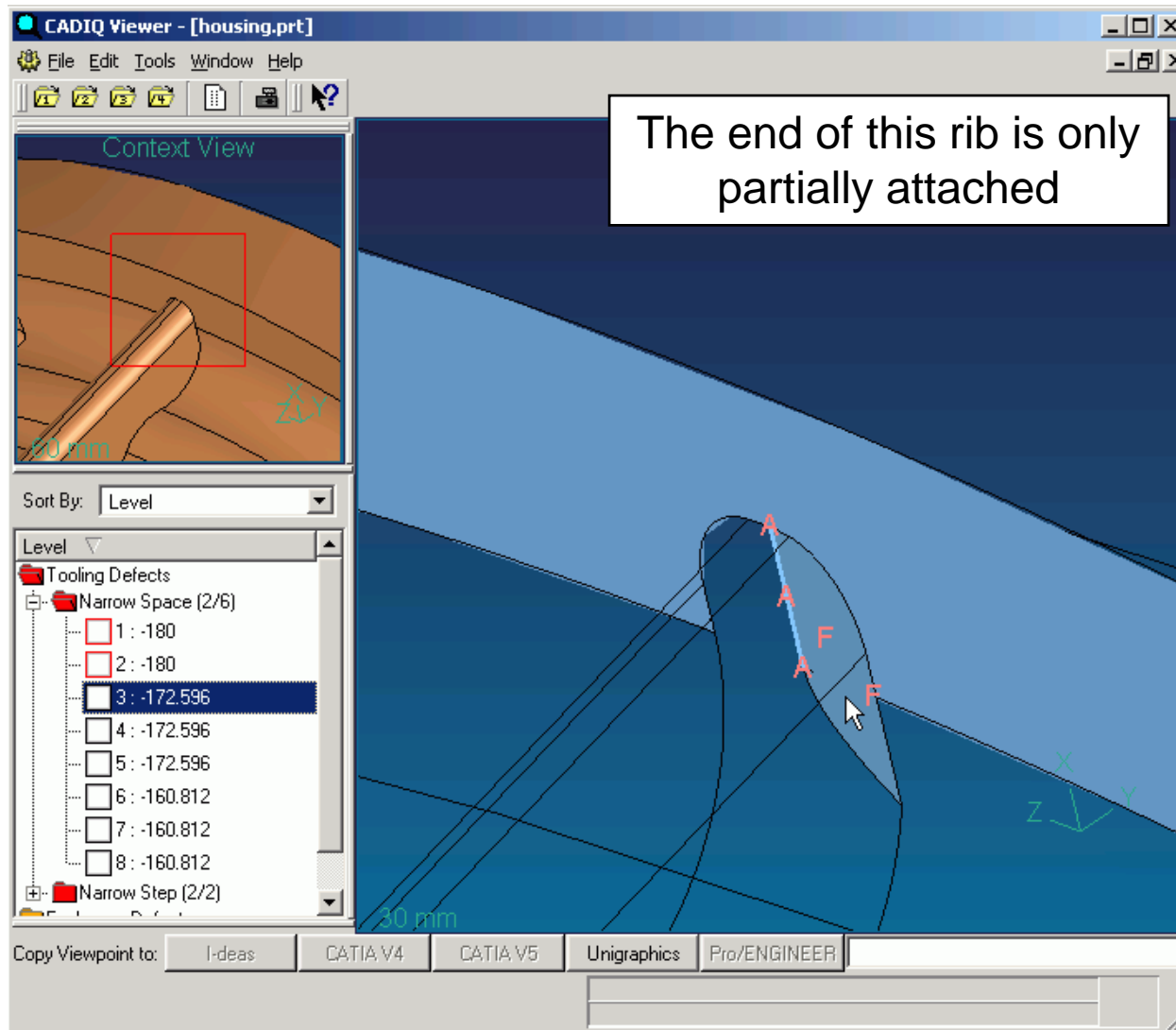


**STEP Translation**  
Minor changes  
but no features

**Feature Translation**  
Major changes

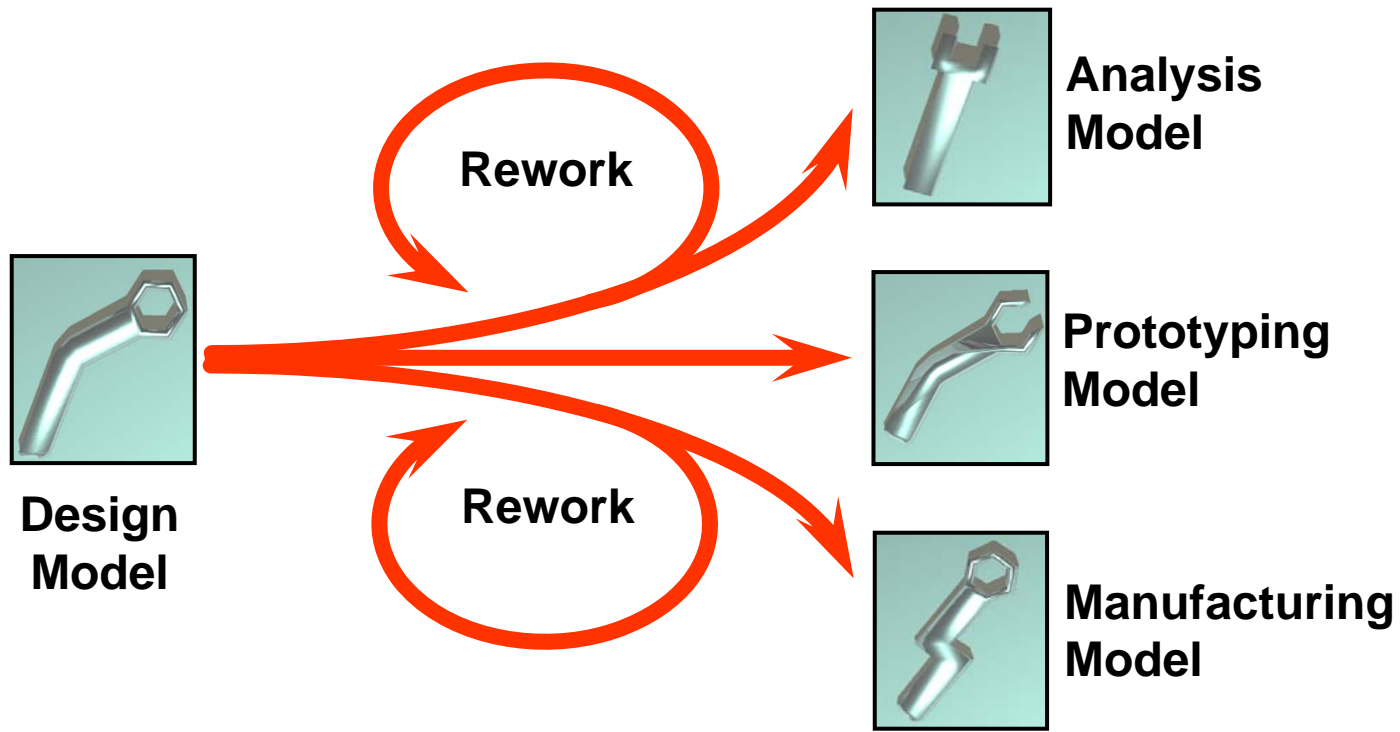
**Manual Remastering**  
Unintentional changes

# Design for Manufacturing Validation

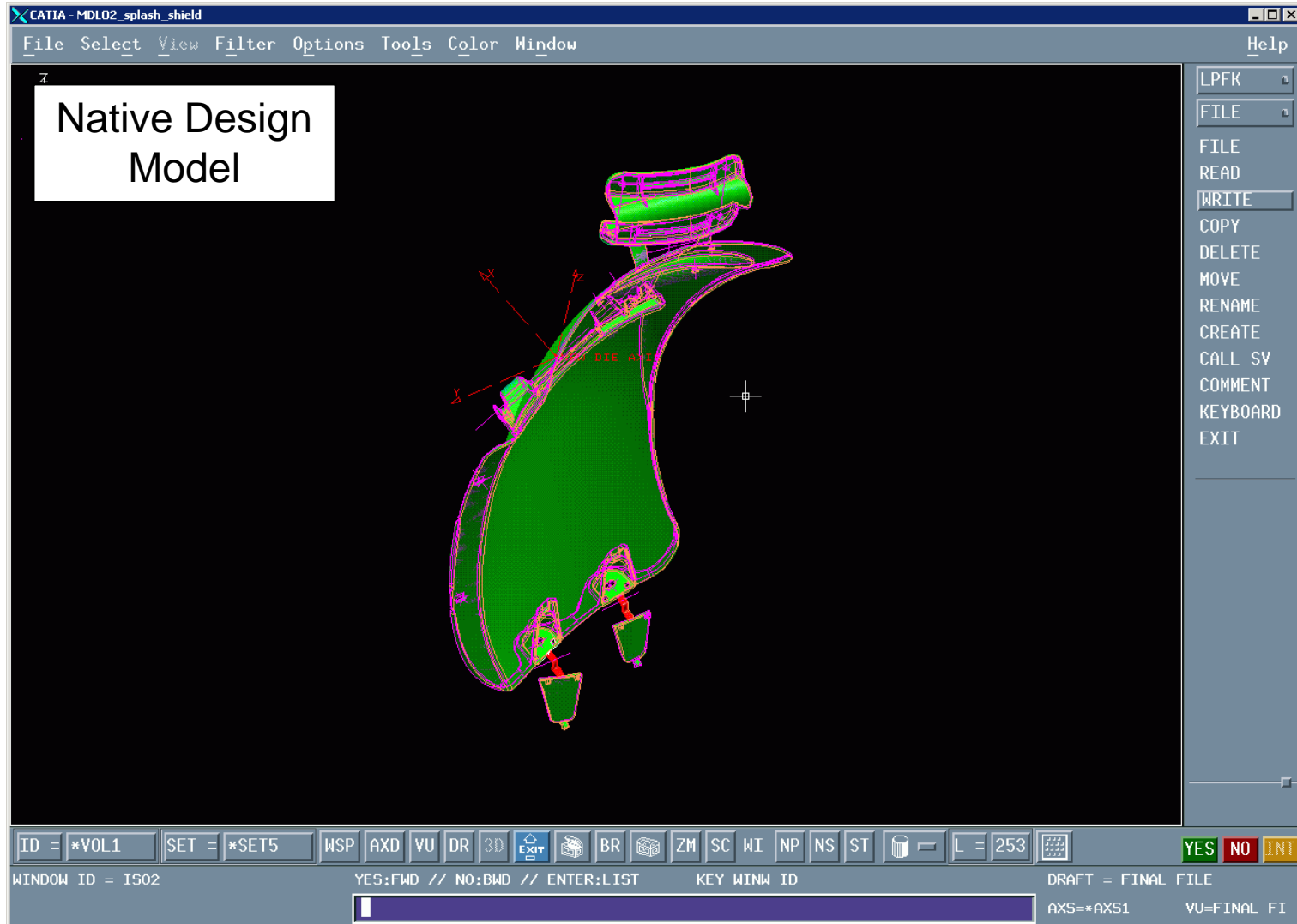


# Design for Manufacturing Validation

- ❑ Unrealistic (*ambiguous*) features in models must be interpreted by downstream users
- ❑ Different interpretations can affect part quality



# Design for Manufacturing Validation

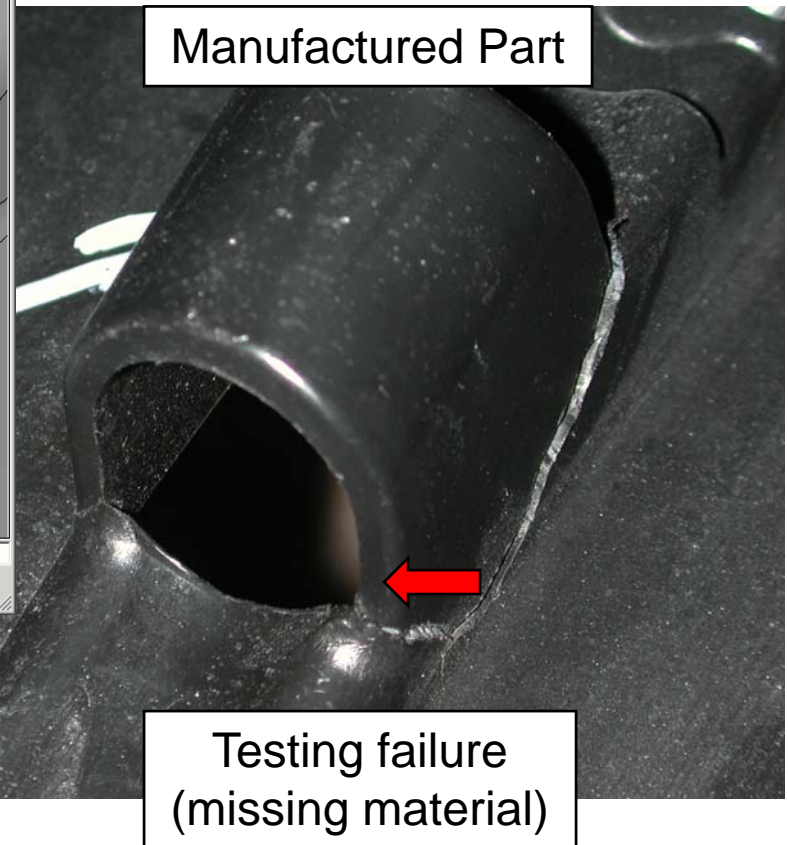
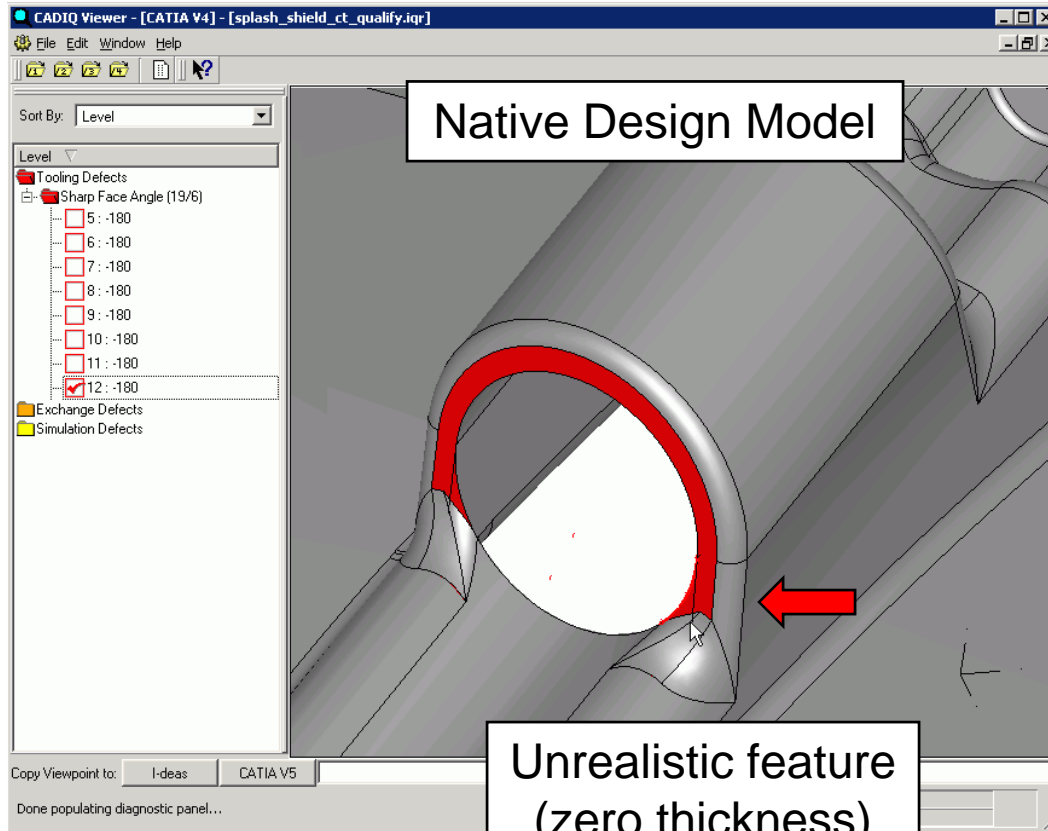


# Design for Manufacturing Validation

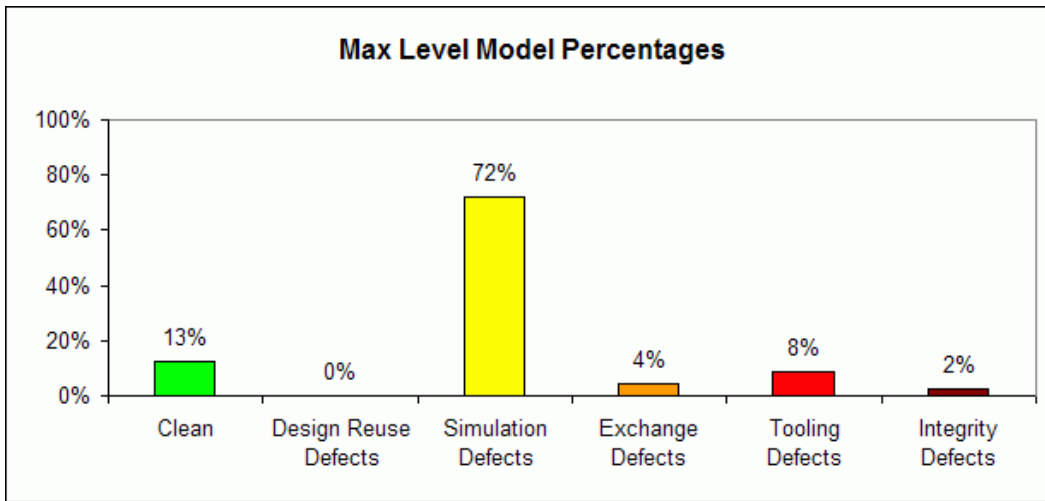
- ❑ Simulation approved the design
- ❑ Manufacturing produced initial parts from native model
- ❑ All parts failed during final testing
- ❑ Caused last-minute schedule delay and retooling



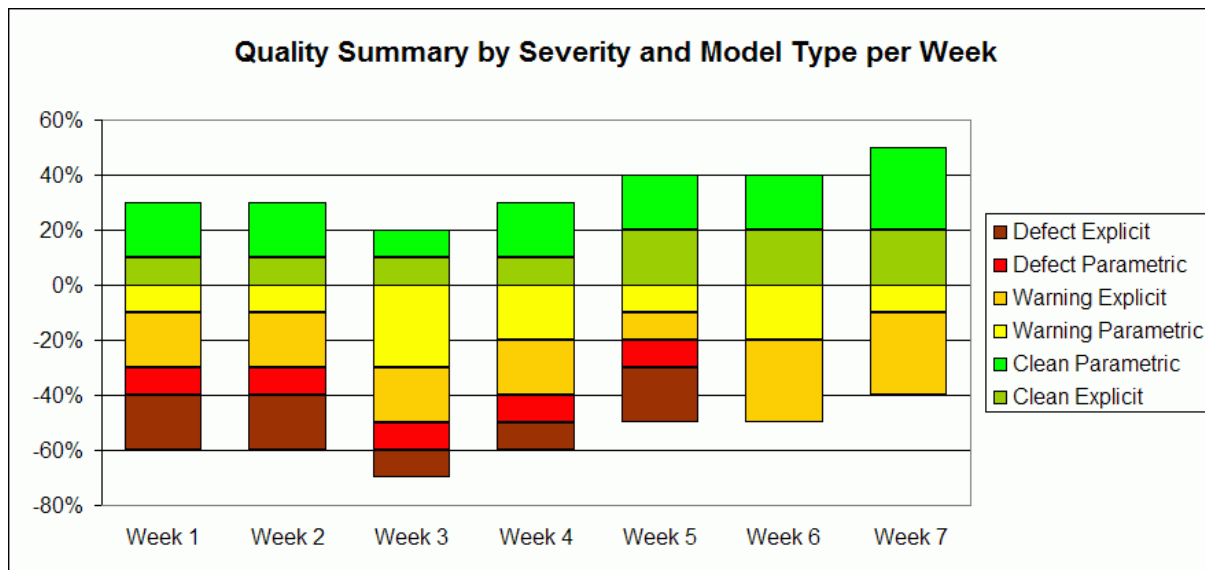
# Design for Manufacturing Validation



# Design for Manufacturing Validation Statistics

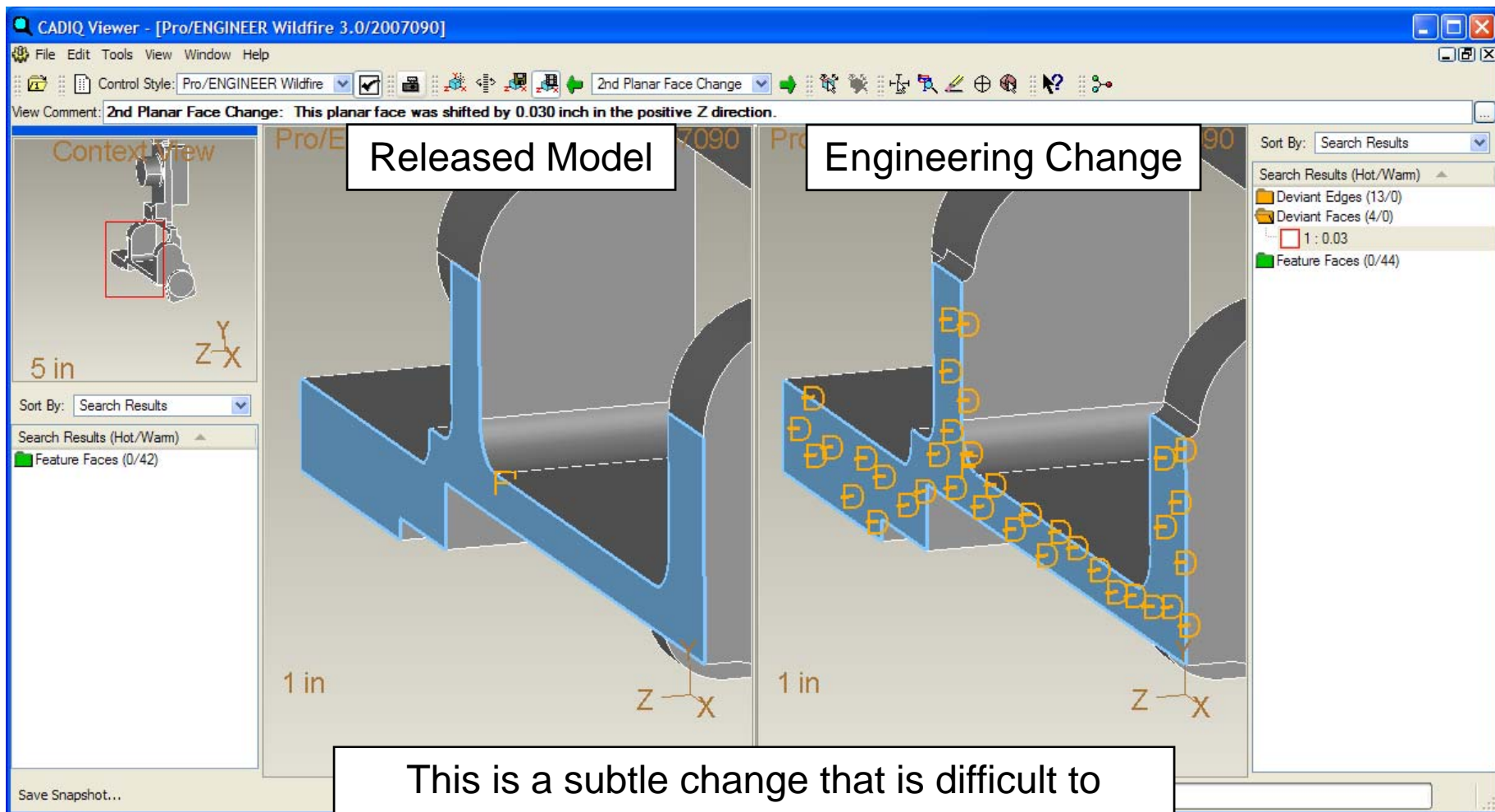


Quality Assessment



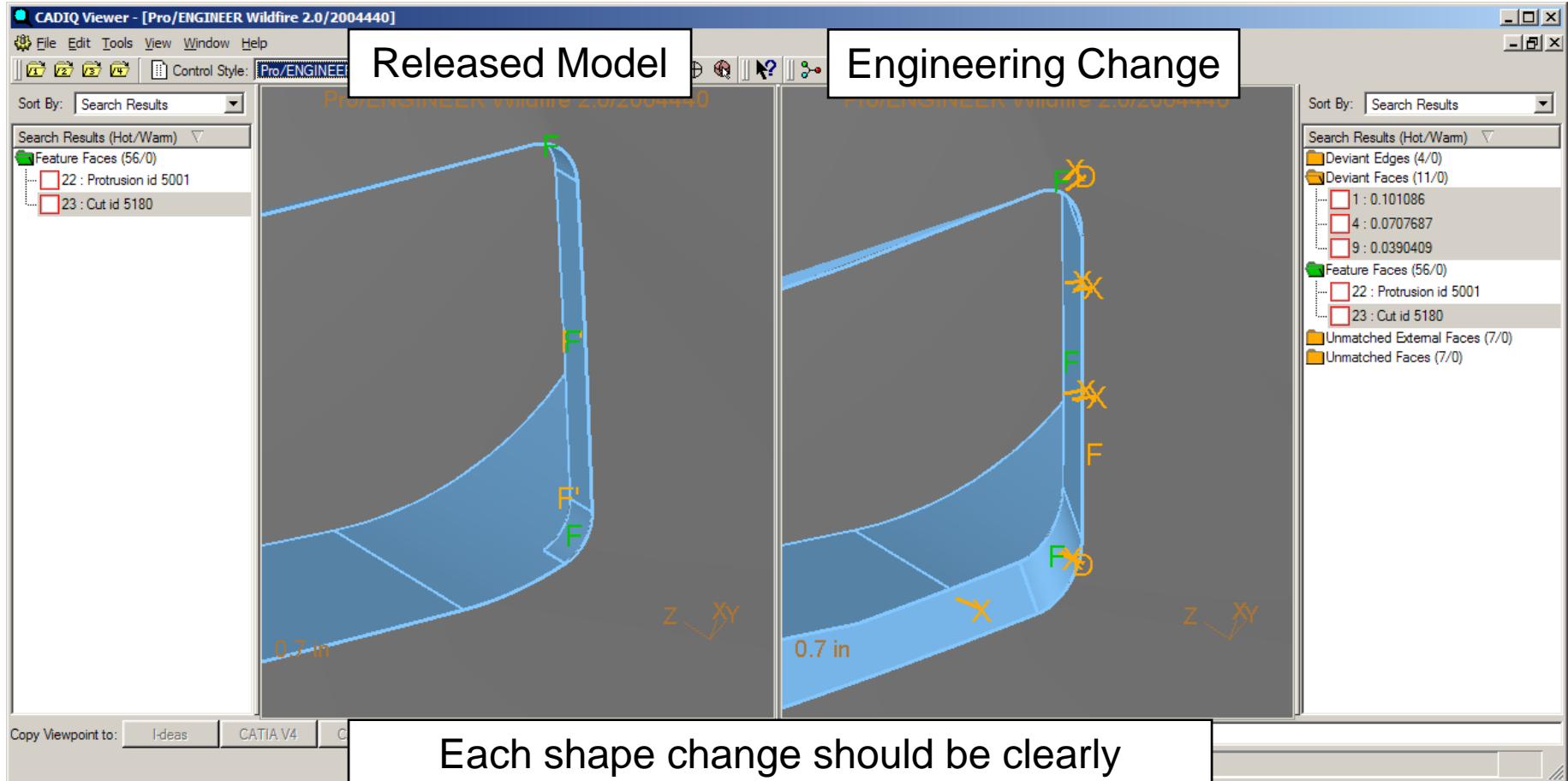
Process Quality Control

# Engineering Change Validation



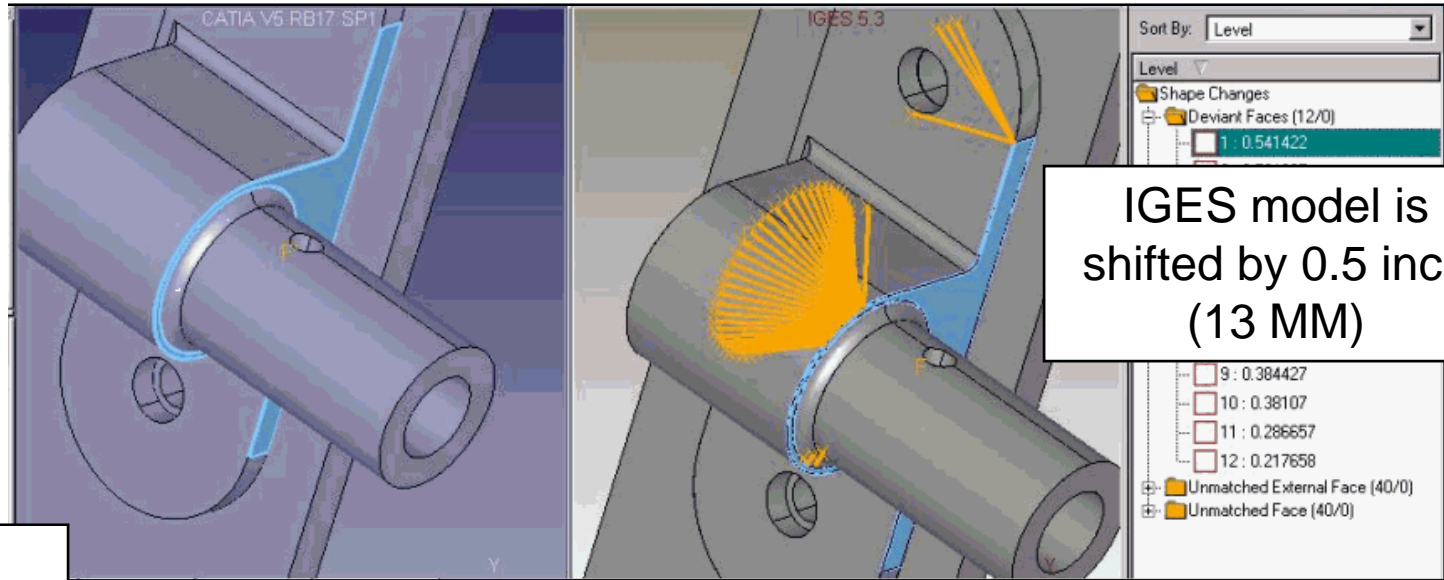
This is a subtle change that is difficult to detect manually and may not be intentional

# Engineering Change Documentation



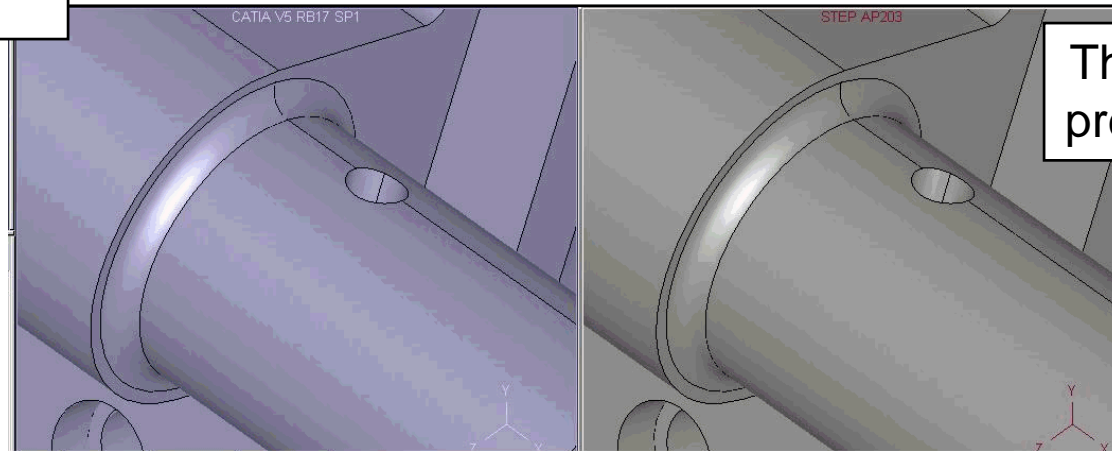
Each shape change should be clearly documented for efficient downstream reuse

# Long-Term Archival Process Comparison



Native CAD  
Assembly

The STEP model is  
precisely equivalent



# Long-Term Archival Validation

**Native CAD Assembly**

**CAD Assembly after STEP export and re-import**

300 mm

300 mm

Context View

900 mm

The highlighted part's position within the assembly has changed

**Defects in Native CAD Assembly:**

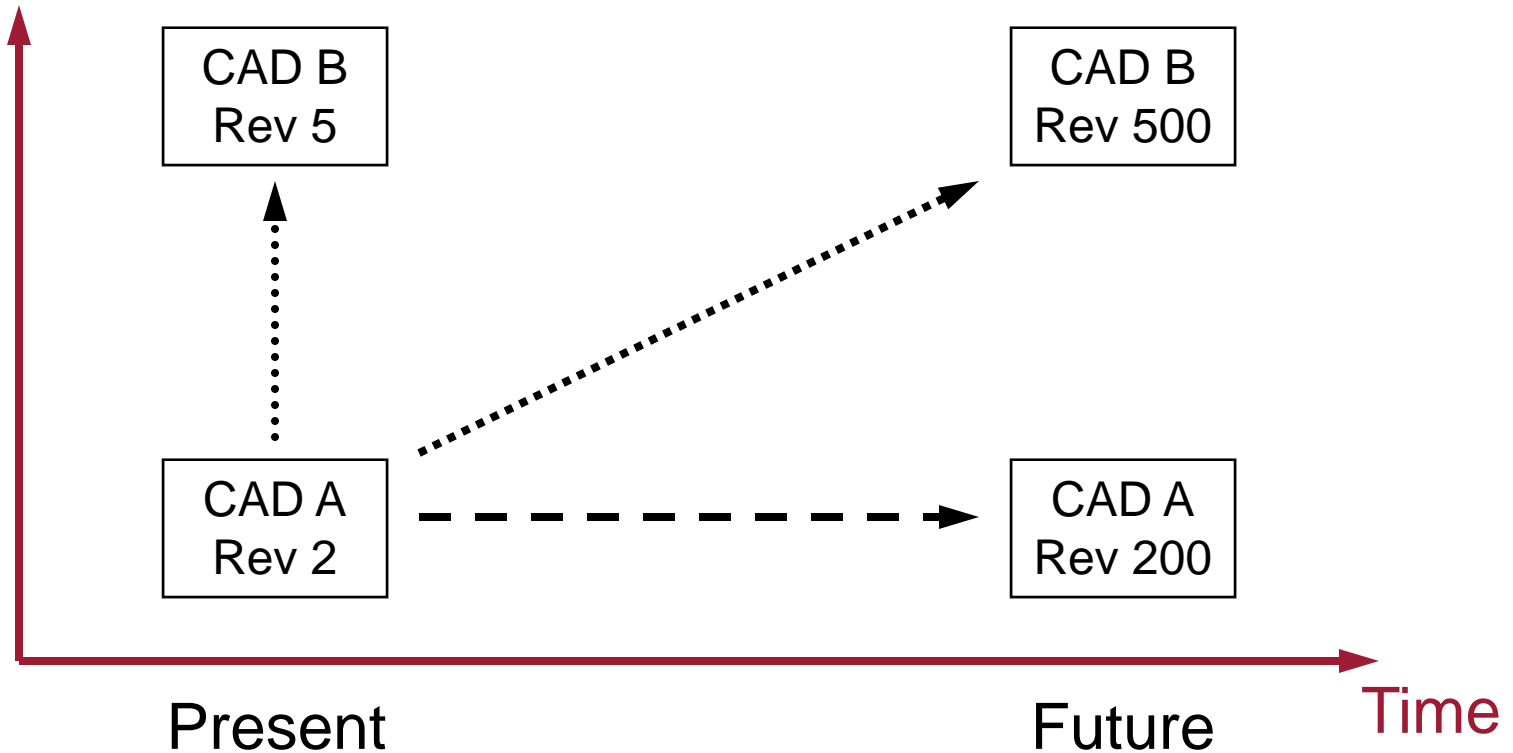
- Integrity Defects
  - Over-Used Edge (12/0)
- Tooling Defects
  - Narrow Space (34/70)
  - Narrow Volume (0/2)
  - Solid Void (48/0)
- Exchange Defects
  - Large Face Gap (4/0)
  - Sharp Face Angle (0/10)
- Simulation Defects
  - Intersecting Loops (4/24)
  - Narrow Face (4/7)
  - Narrow Region (0/48)
  - Self-Intersecting Loop (2/0)
- Design Reuse Defects
  - Multi-Solid Model (89/0)
- Design Information
  - Feature Faces (560/0)

**Defects in CAD Assembly after STEP export and re-import:**

- Property Changes
  - Different Face Area (0/22)
  - Different Solid Location (8/0)
- Tooling Defects
  - Narrow Space (34/71)
  - Narrow Volume (24/2)
  - Solid Void (48/0)
- Shape Changes
  - Deviant Faces (16/0)
  - Unmatched External Solid (7/0)
  - Unmatched Faces (24/0)
  - Unmatched Solid (7/0)
- Exchange Defects
  - Sharp Face Angle (0/8)
- Topology Changes
  - Complex Face Match (31/0)
  - Merged Face (12/0)
  - Split Faces (23/0)
- Simulation Defects
  - Intersecting Loops (16/12)
  - Narrow Face (4/6)
  - Narrow Region (24/26)
  - Self-Intersecting Loop (2/0)
- Design Reuse Defects
  - Multi-Solid Model (100/0)

# CAD Translation Space-Time Continuum

Space



Long-term archival translation problems  
are unknowable.  
But they can be indicated by  
present CAD-to-CAD translation problems.

# STEP Translation Validation

**Legacy Model**

Level

Change Defects

Large Face Gap (4/3)

- 3 : 0.804649
- 4 : 0.804649
- 5 : 0.804649
- 6 : 0.804649
- 7 : 0.012244

Simulation Defects

**STEP Model**

Sort By: Level

Level

Exchange Defects

Large Face Gap (2/9)

- 3 : 0.183982
- 4 : 0.183982
- 5 : 0.0159115
- 6 : 0.0159115
- 7 : 0.0122444
- 8 : 0.0115305
- 9 : 0.0112968
- 10 : 0.0112968
- 11 : 0.0102062

Topology Changes

**Translated Model**

Sort By: Level

Level

Form Changes

Integrity Defects

Sharp Free Edge An

- 1 : 180
- 2 : 180
- 3 : 180
- 4 : 180
- 5 : 180
- 6 : 179.971
- 7 : 179.679
- 8 : 176.952
- 9 : 176.952

Quality defects and shape changes caused by extreme gap in native model

Not a Solid

2 mm

Copy Viewpoint to: I-deas CATIA V4 CATIA V5 Unigraphics Pro/ENGINEER

# STEP Translation Validation

**Legacy Model**

**STEP Model**

**Translated Model**

Quality defects and shape changes caused by poor surface approximation during STEP export

**Not a Solid**

CADIQ Viewer - [pm13-ug-214.prt V5, pm13-ug-214.stp and pm13-ug.mf1]

File Edit Tools Window Help

Search Results

Results (Hot/Warm)

Sort By: Search Results

Search Results (Hot/Warm)

- Deviant Faces (4/4)
  - 2: 0.0469695
- Large Face Gap (2/9)
  - 5: 0.0159115

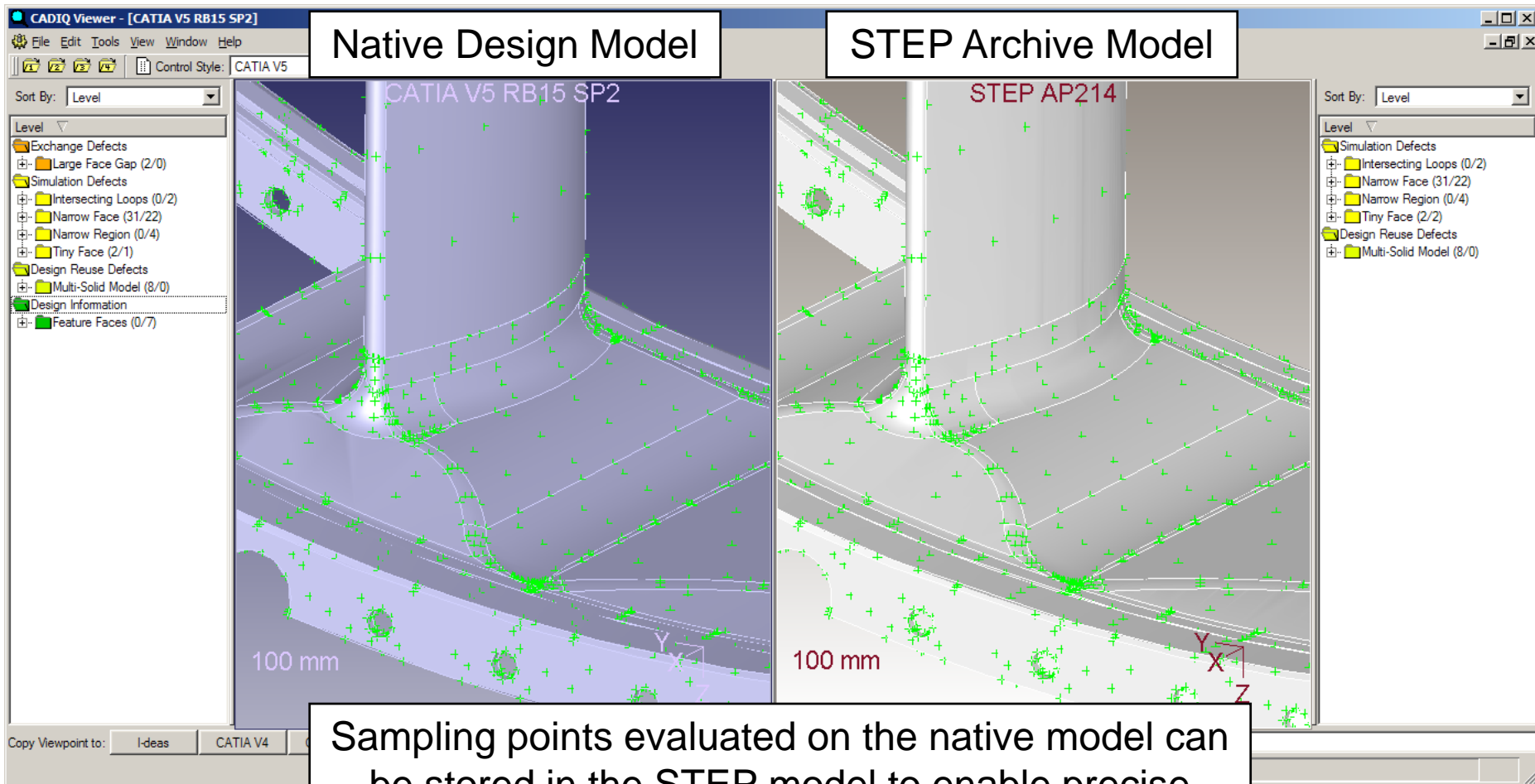
Context View: pm13-ug-214.prt

10 mm

30 mm

Copy Viewpoint to: I-deas CATIA V4 CATIA V5 Unigraphics Pro/ENGINEER

# Long-Term Archival Validation Properties



Sampling points evaluated on the native model can be stored in the STEP model to enable precise validation after retrieval into a future CAD system

# Validating More Than Just Geometry

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## ❑ Collaboration Model Validation

- CAD to 3D PDF
- CAD to JT

## ❑ Assembly Structure

- Duplicate instances, interferences, narrow spaces
- Structure changes

## ❑ Product Manufacturing Information (PMI)

- 3D geometric dimensions and tolerances (GD&T)
- Annotations (notes)
- Model attributes

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## Questions?

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