



DOE/NNSA Kansas City Plant

Product Tolerance Representation Critical Requirements for Product Definition and Metrology Interoperability

Technology that Reduces the Complexity of:

*Representing & Exchanging Fully Semantic Model-Based Tolerancing &
Generating Correct CMM Measurement Programs for Rapid Certification*



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Principal Mechanical Engineer

MBE/TDP Summit
12 December 2011



The Kansas City Plant is Operated for the
United States Department of Energy under
Contract No. DE-NA0000622

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Why Men Do Not Live as Long as Women?

Your Safety Tip(s) for Today

Standing on a bucket on TOP of a ladder, brilliant



Ummm? At least someone's holding the ladder steady



Wonder what HE makes an hour? It can't be enough.



Oh yeah, THAT's safe!



No problem, I can see through the holes.



It starts at a young age and just gets worse.



You hold it while I whack it with this hammer.



A new OSHA approved substitute for ladders



Ropes are for sissies



Now, I wanna know why?



Who is the Kansas City Plant?

Established by DOE in 1949 with over 3.2 million ft², 2800+ people

- **Classified Secured Facility**
- **Managed and Operated by Honeywell Federal Manufacturing & Technology**
- **Primary Mission: Build & Sustain Non-Nuclear Portions of the Nuclear Arsenal**
- **Engineering & Manufacturing are Primary Core Competency's - very diverse capabilities**
- **Responsible to provide (make and/or purchase) 100,000 + items for DOE**
- **Mission includes partnering with**
 - **Other Government Agencies - Work for Others (WFO) Program; and**
 - **Companies – Cooperative Research & Development Agreement (CRADA)**



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Agenda

Fully Semantic Tolerance Definition (PMI)

- **Understanding**
- **Critical Requirements**
- **Enablers to Manage Complexity**
 - **Feature-Based Tolerancing (FBTol) Brief**
 - **Feature-Based Measuring (FBMeas) Brief**
 - **Optional Demonstration (via .wmv video)**
- **Progress PMI Agenda (Way Forward)**
 - **Collaboration**

Overview

- **Status of Complete & Unambiguous Product Modeling**
 - Today's product definition systems *successfully deliver* the representation and exchange of *nominal shapes*.
 - Unfortunately, *no one can manufacture nominally shaped parts*.
 - *However, we can make parts that fit and function* according to correctly specified and accurately conveyed product tolerances.
 - **Correct, complete & unambiguous, and verified tolerance definitions are the critical enabler for realizing:**
 - successful representation, consumption, and/or exchange of product models for next generation automation applications
 - return on investment promised by MBE
 - **Presently, there is likely no single CAD-based system available with the level of robustness to adequately represent and transfer product tolerance information.**

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Overview

- **Status of Complete & Unambiguous Product Modeling**
- **Requirements for a Fully Semantic Tolerance Definition**

Overview

- **Status of Complete & Unambiguous Product Modeling**
- **Requirements for a Fully Semantic Tolerance Definition**
- **Basic Understanding of Model-Based Product Tolerance Technology**

Overview

- **Status of Complete & Unambiguous Product Modeling**
- **Requirements for a Fully Semantic Tolerance Definition**
- **Basic Understanding of Model-Based Product Tolerance Technology**
- **Promote a Fully Semantic Representation and Exchange of Tolerance Definitions**
 - **Representation vs Presentation (Annotation)**
 - FBTol
 - **Tolerance Related Standards**
 - ASME Y14.X
 - ISO 13030 STEP AP203e2
 - ISO 13030 STEP AP242
 - **Process Related Standards**
 - ISO 13030 STEP AP238
 - DMSC's QIF - QMP

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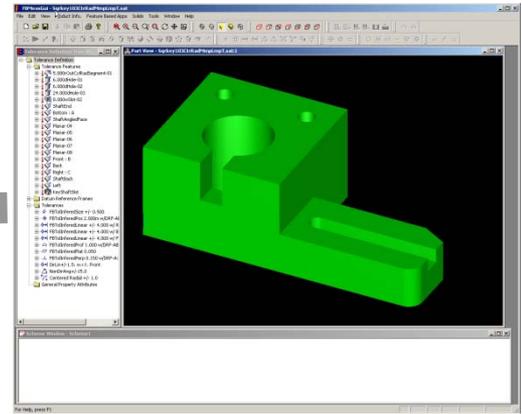
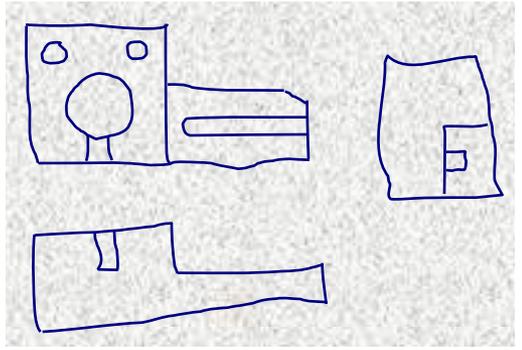
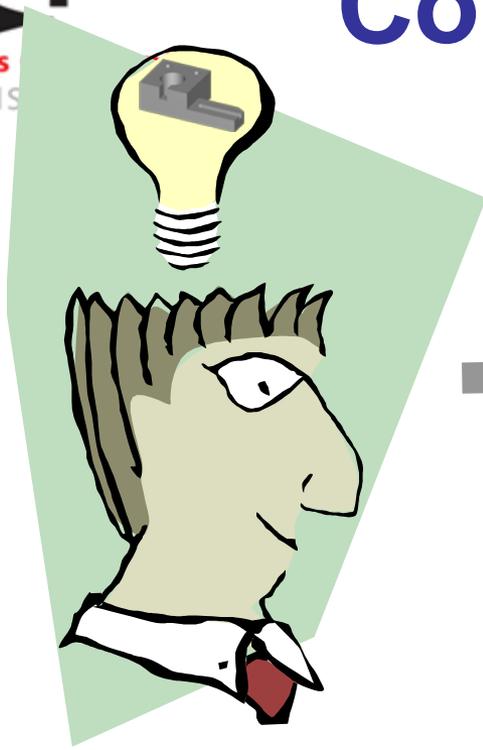
Overview

- **Status of Complete & Unambiguous Product Modeling**
- **Requirements for a Fully Semantic Tolerance Definition**
- **Basic Understanding of Model-Based Product Tolerance Technology**
- **Promote a Fully Semantic Representation and Exchange of Tolerance Definitions**
- **Demonstrate a Product Tolerance Application and Rapid Metrology Generation Application (optional)**

Overview

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- **Basic Understanding of Model-Based Product Tolerance Technology**
- **Promote a Fully Semantic Representation and Exchange of Tolerance Definitions**
- **Demonstrate a Product Tolerance Application and Rapid Metrology Generation Application (optional)**
- **Investigate Opportunities to Progress the Realization of Investments Promised by Model-Based Enterprise.**

Concept to Design to Functional Part



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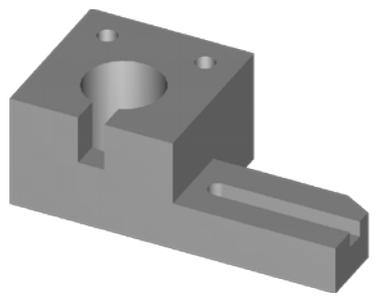
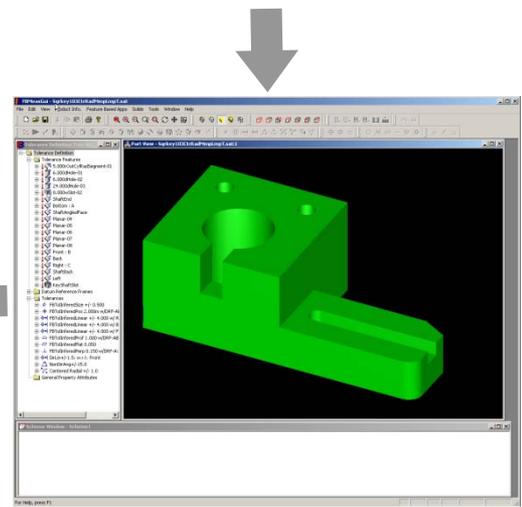
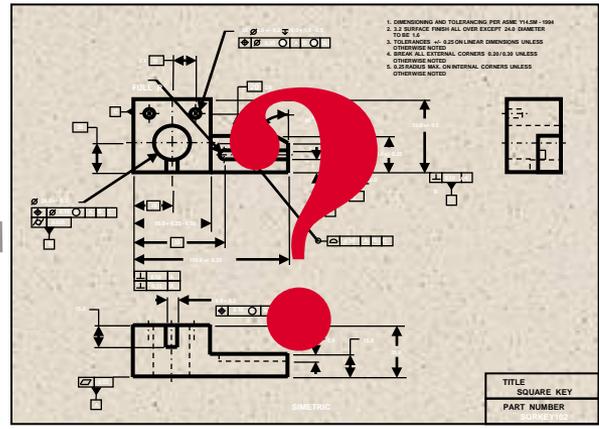
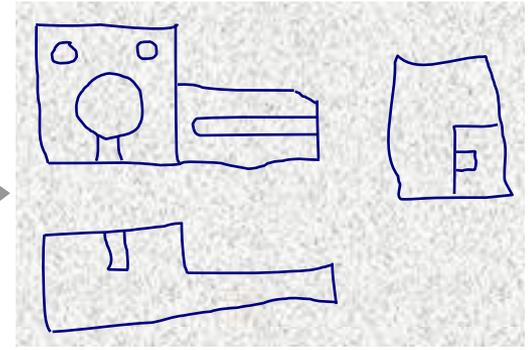
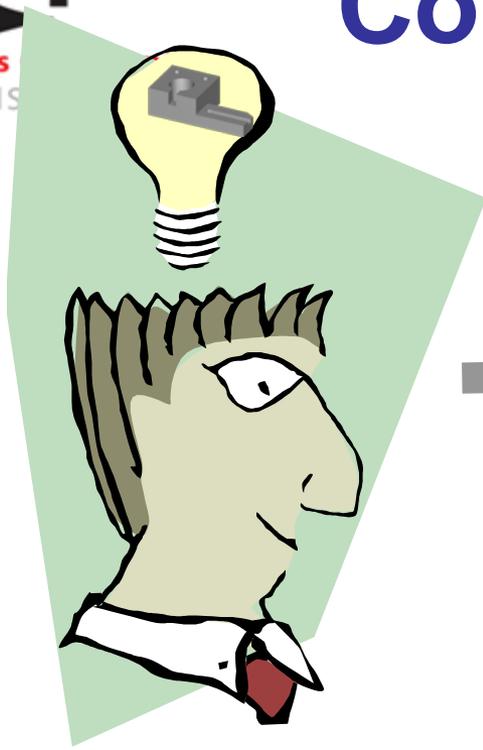
Regrettably

**“Nobody can build perfect parts....
but we can build parts that fit and
function,

by applying and communicating
functional product tolerance
information.”**

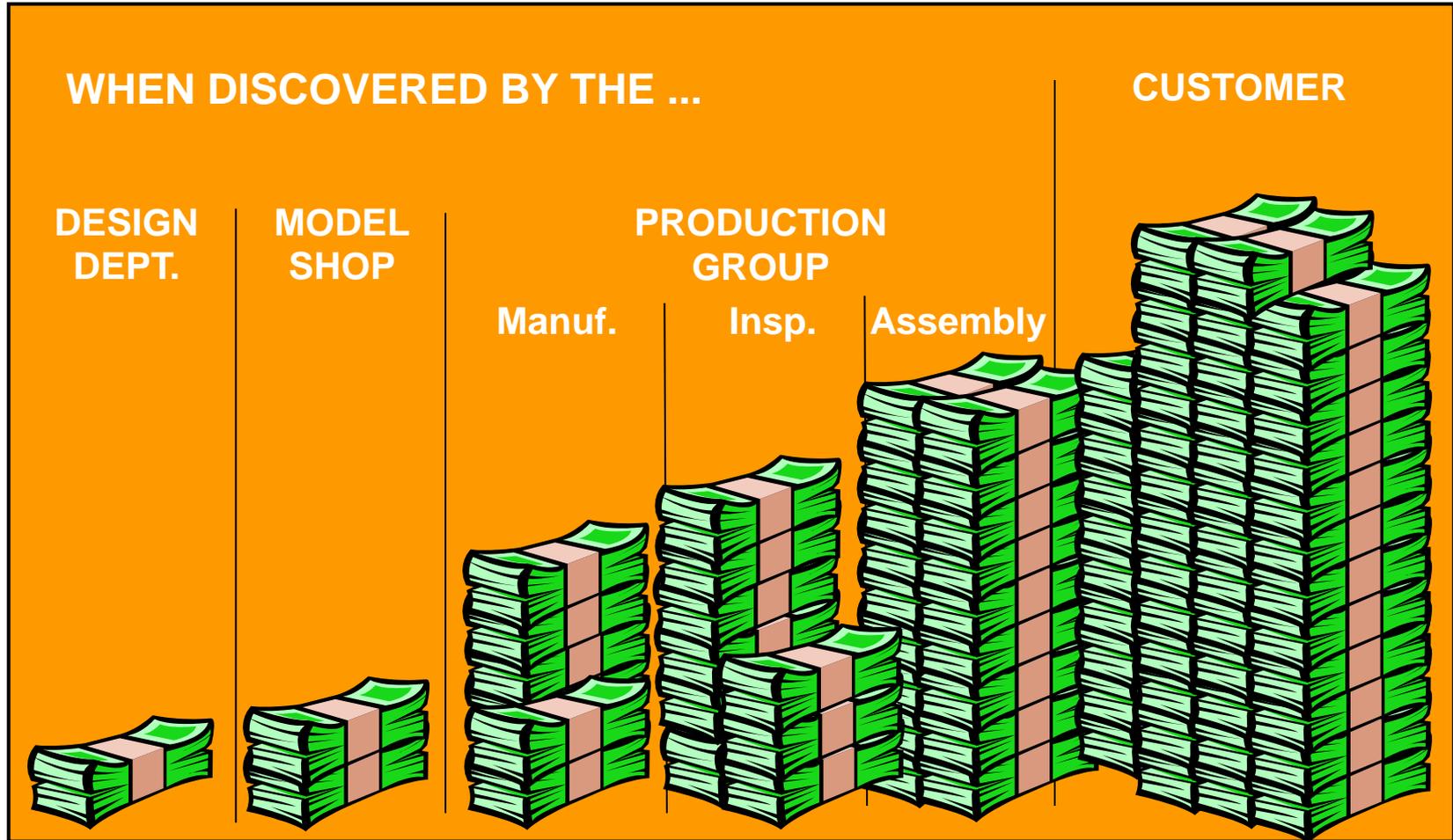
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Concept to Design to Functional Part



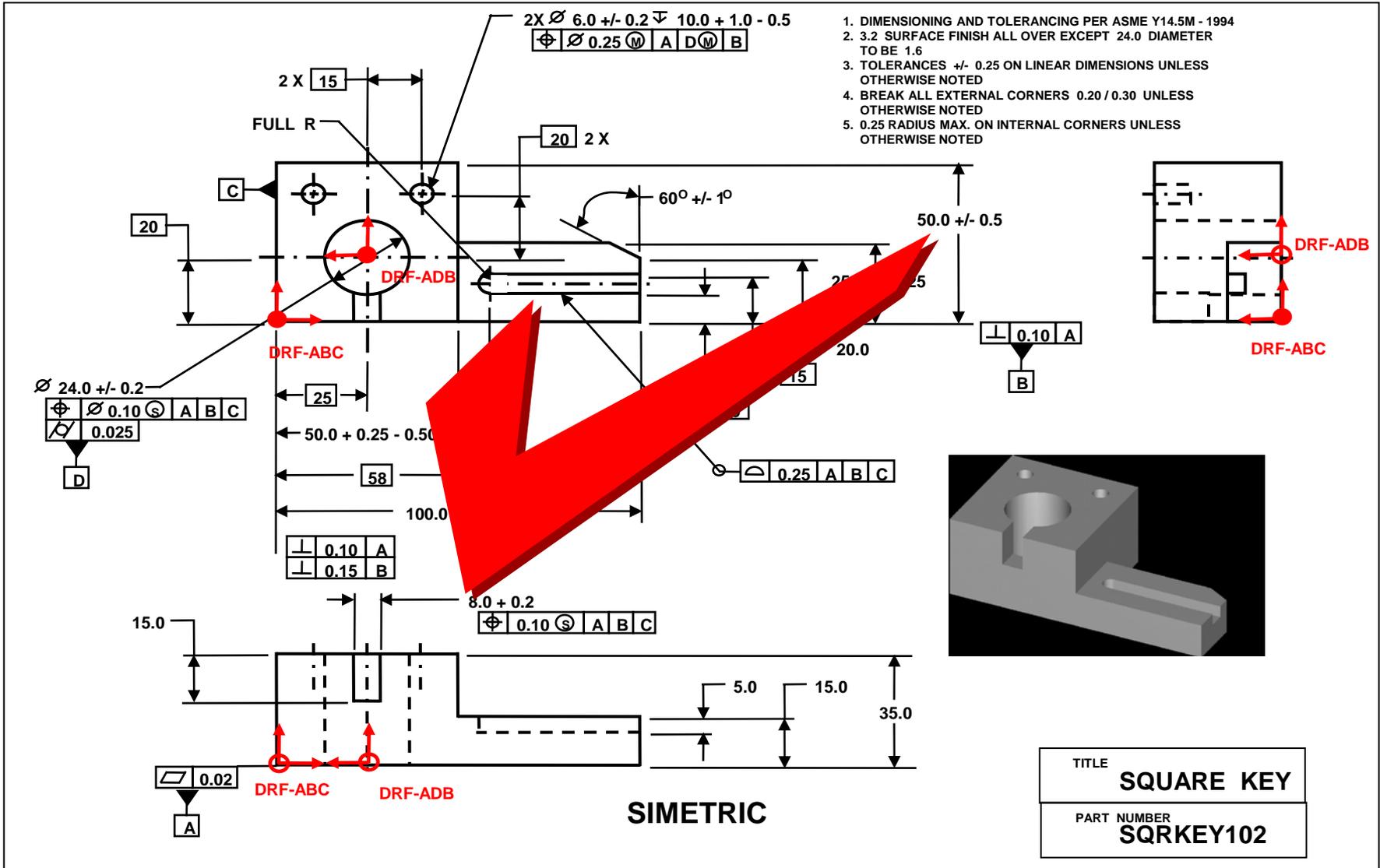
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Cost of a Design Error



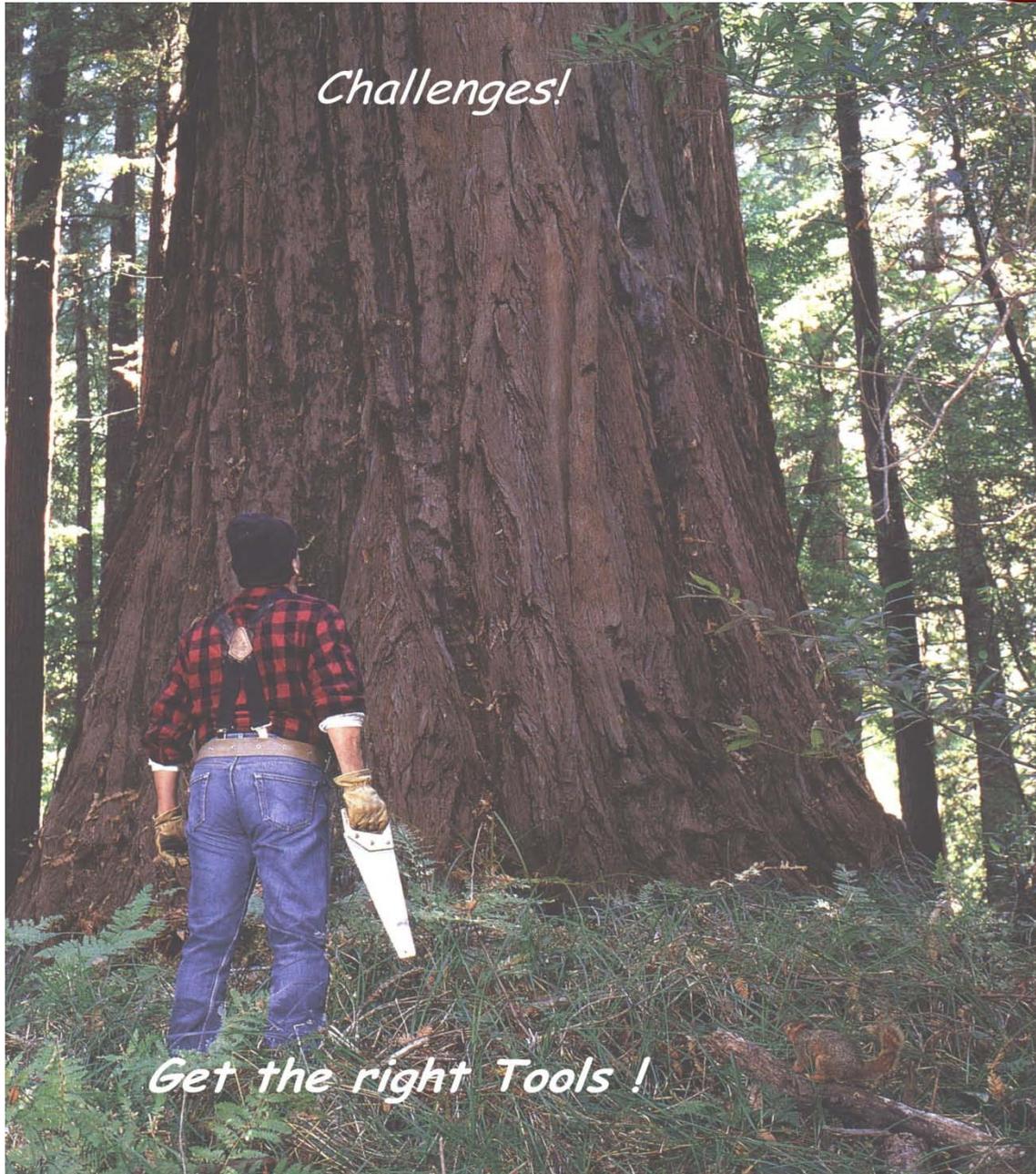
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Tolerance Checking



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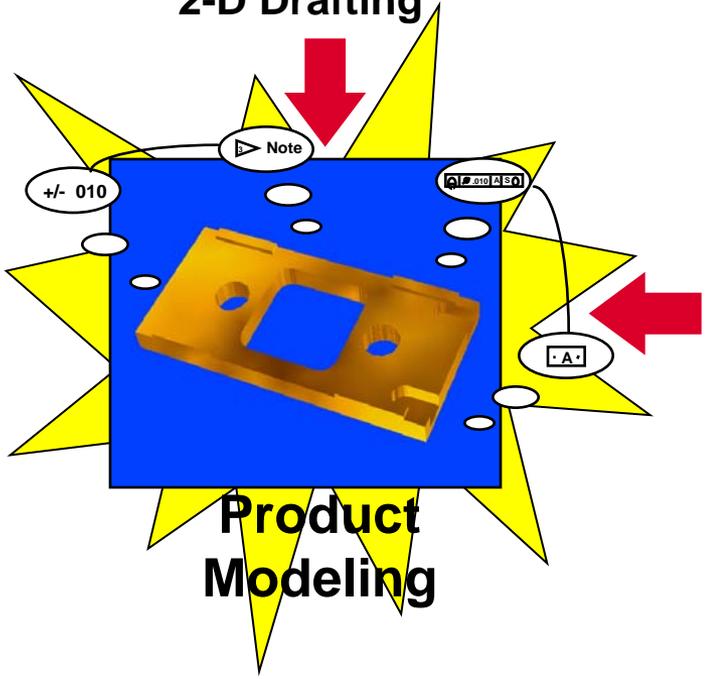
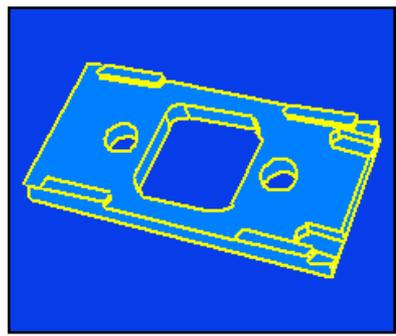
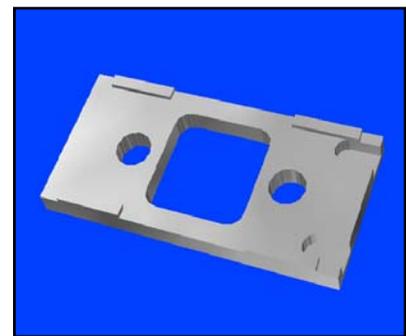
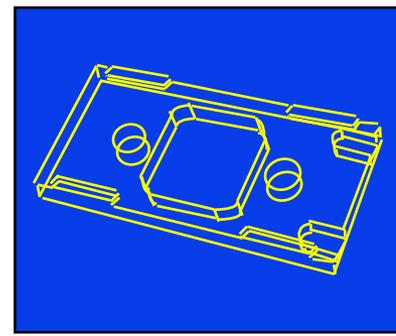
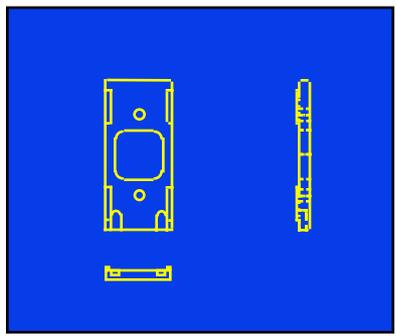
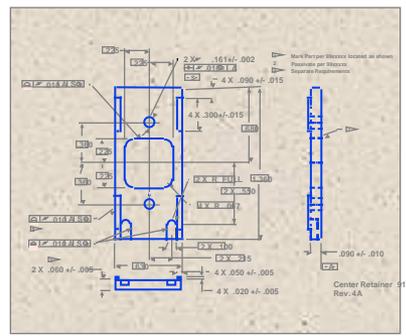
Challenges!



Get the right Tools !

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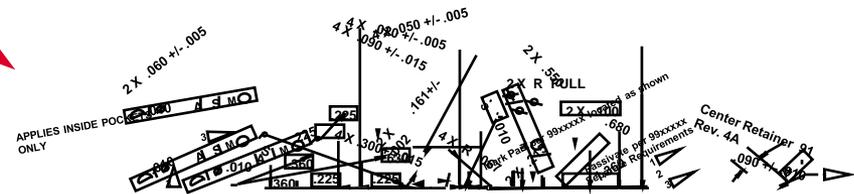
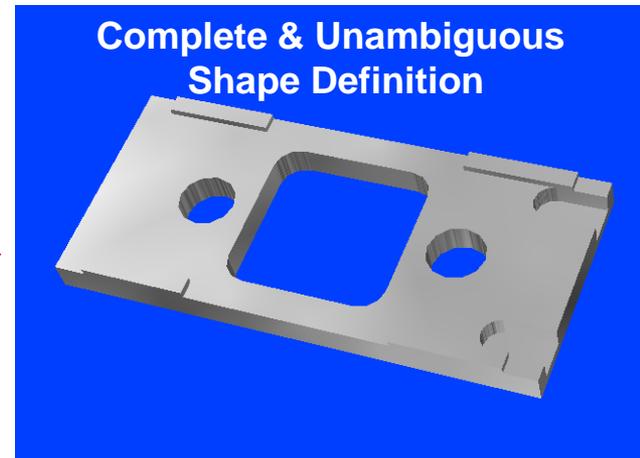
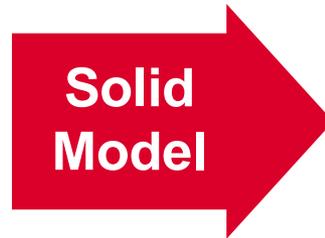
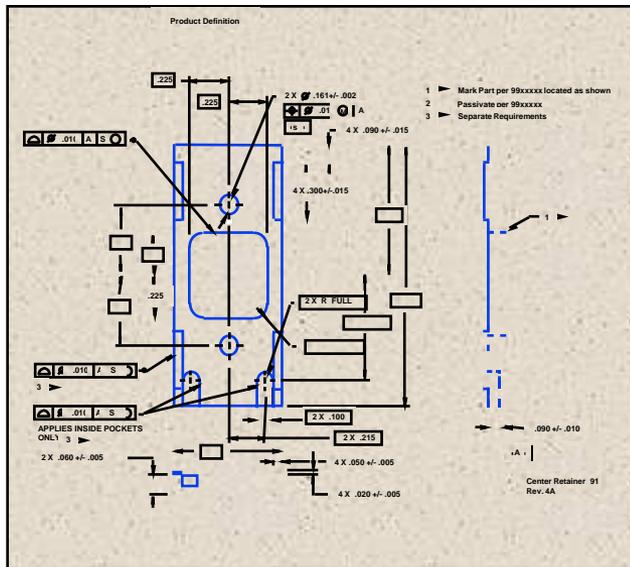
Transformation of Product Definition



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Current Product Definition Challenges

INCOMPLETE AND AMBIGUOUS PRODUCT DEFINITION

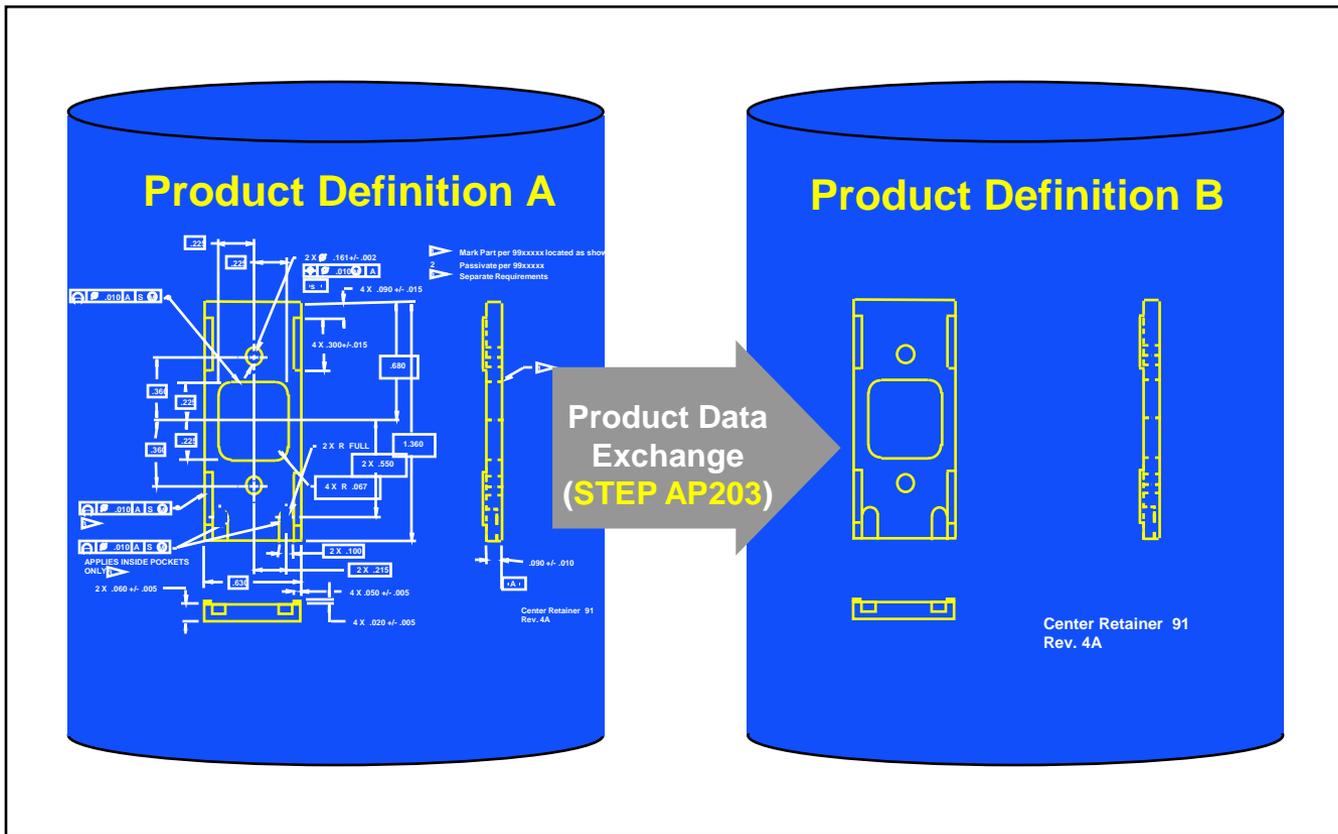


Incomplete & Ambiguous
Non-Shape Attributes
(e.g., Tolerances, General Property Attributes)

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Current Product Definition Challenges

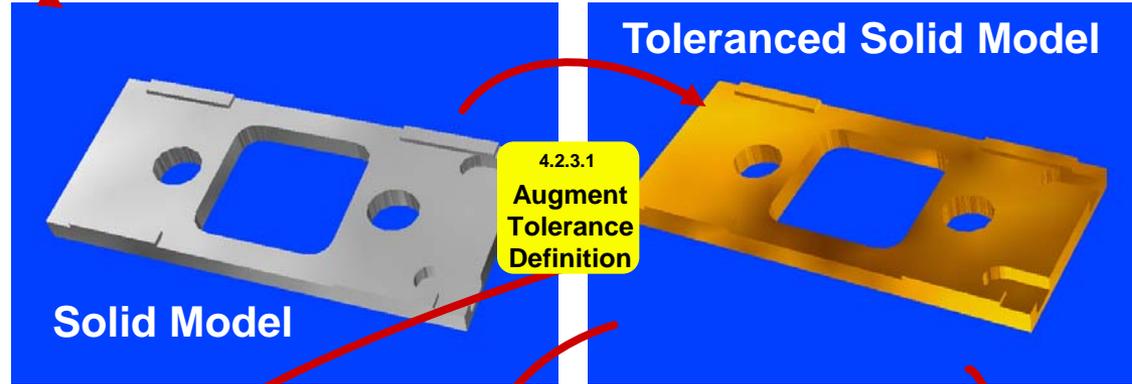
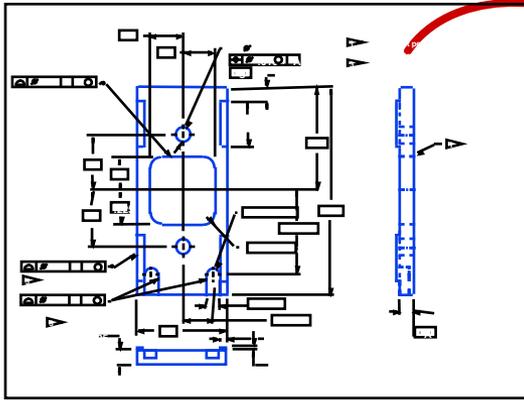
INCOMPLETE PRODUCT DATA EXCHANGE



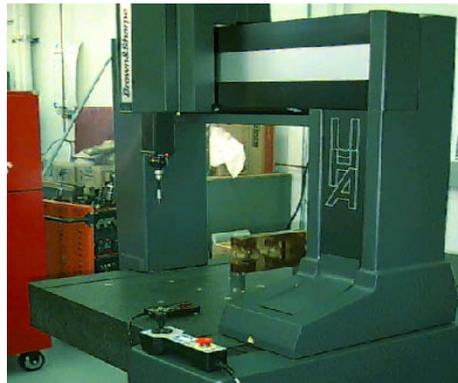
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Current Product Definition Challenges

Augment Product Tolerance Information for Downstream Applications

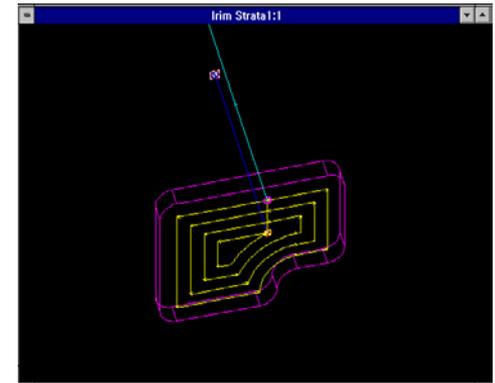


**CMM
Part
Program
Generation**



Other Applications

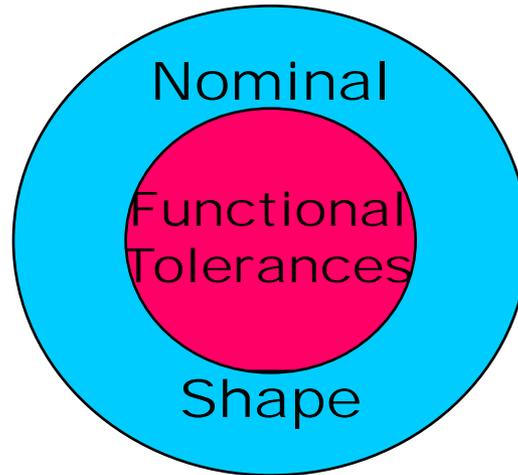
- Tolerance Analysis
- Assembly Analysis
- Process Planning
 - Manufacturing
 - Measurement
- Measurement Results Analysis



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So What's the Problem?

Current *electronic* product definition systems represent and/or exchange *only a segment* of the required product's design completely and unambiguously.



NEED: Fully Semantic, Complete, Unambiguous & Correct Tolerance Definition, NOT just Annotations!

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Product Model Tolerances

**“It is the representation,
not the presentation.”**

**“One can create the presentation
(e.g., ASME Y14.41)
from a validated representation.”**

ISO 2768-1

“The Designer’s Challenge”

“Tolerancing ... should be **complete** to ensure that *all aspects of a feature* are **controlled**. **Nothing shall be implied** or left to judgement in the workshop or in the inspection department”

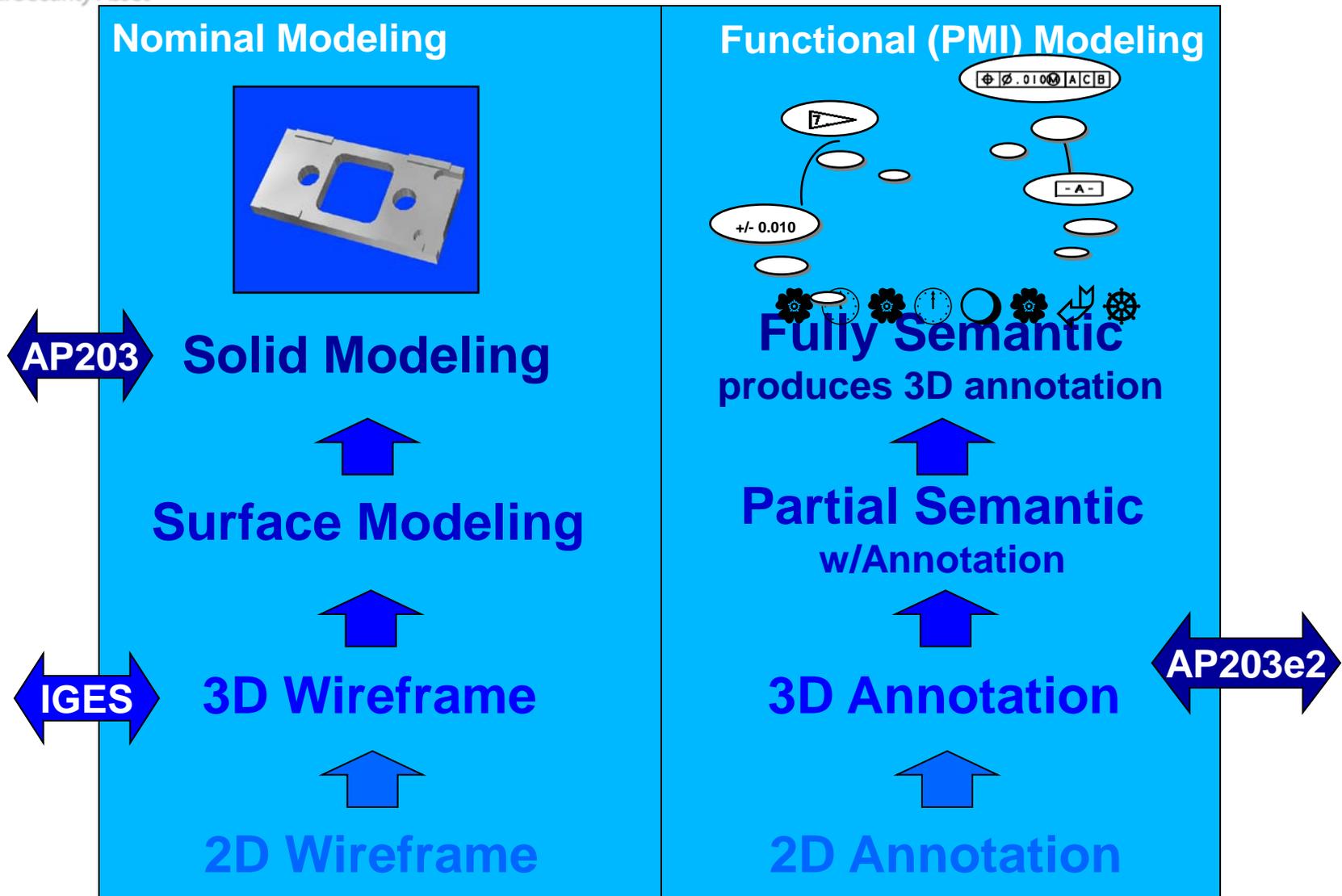
Model-Based Tolerance Requirements

- Augment a Solid Shape w/ Product Tolerances
- Implement the Notion of Tolerance Features (collection of one or more topological face entities)
- Fully Semantically Represent Tolerances
 - Dimensional / Coordinate Tolerances (e.g., Size, Distances, Angles)
 - Geometric Tolerances (e.g., Position, Profiles, Flatness, Perpendicularity)
 - Surface Textures
 - Specifications (e.g., Thread Specs., Welding)
 - General Property Attributes (e.g., Notes, Markings, Cosmetics)
 - Criticality Designation
- Designate Functionally Important Tolerance Features as Functional Datum Features
- Build Datum Reference Frames from Datum Features
- Assign DRFs to Appropriate Tolerances

Model-Based Tolerance Requirements

- Purposely Associate Tolerances to Appropriate Tolerance Feature(s)
- Recognize Tolerance Features (Auto, Interactive)
- Infer Correct Tolerances Automatically
 - Per ANSI Y14.5
 - Per Company Standards
- Check, Validate, & Score Piece-Part's Functional Tolerance Definition
- Publish Application Programmers Interface Suite
 - Extend Tolerance Analysis
 - Integrate with Existing Applications
 - Support Downstream Applications (e.g., Measurement)
- Exchange Tolerance Definition to other Product Definitions *We make products for national security.*

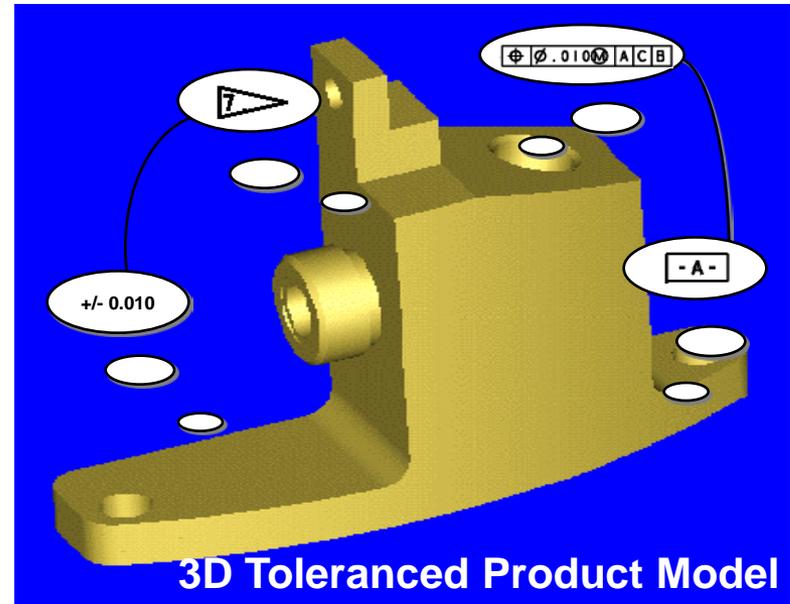
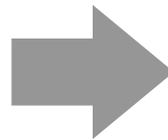
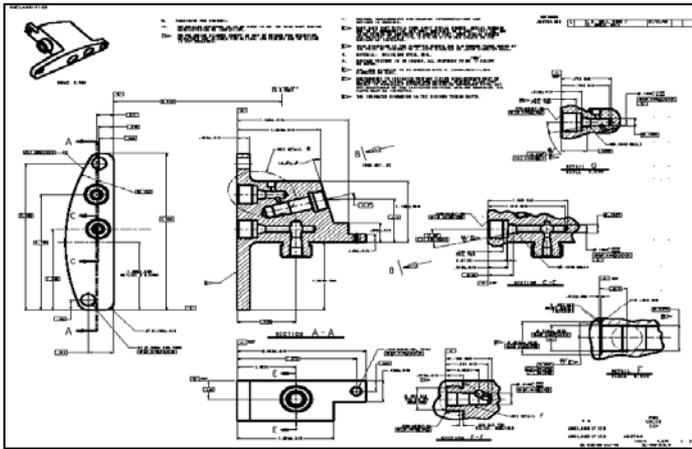
Mechanical Model-Based Progression



FBTol progresses Annotation like Solid Modeling progressed Wireframes

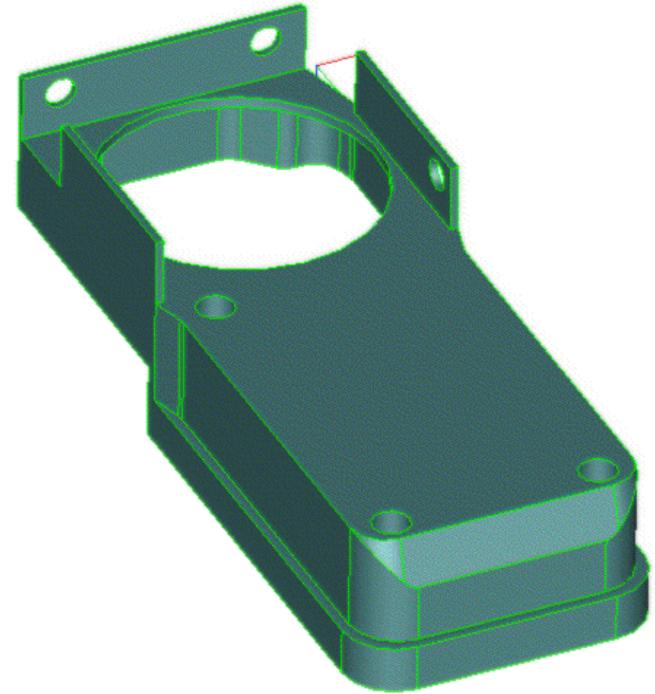
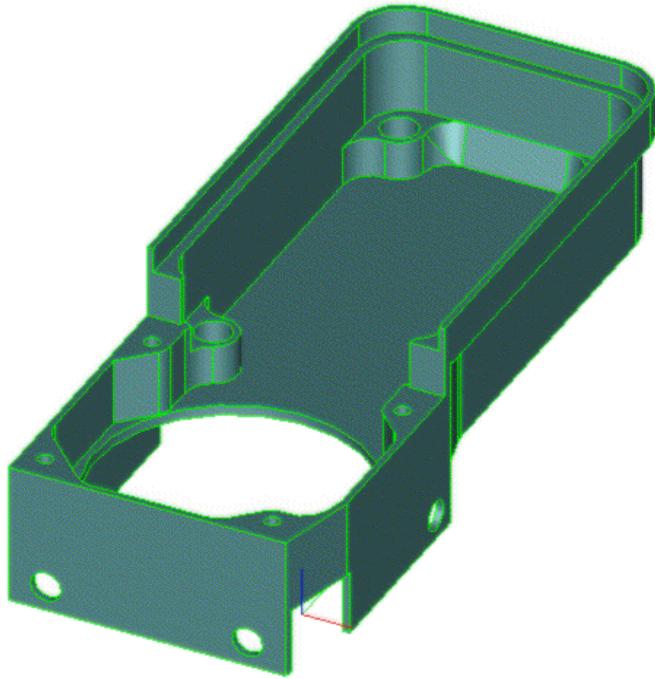
Feature-Based Tolerancing™

a Component Technology for
Fully Semantic Product Modeling.



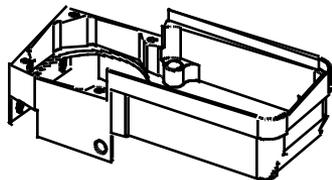
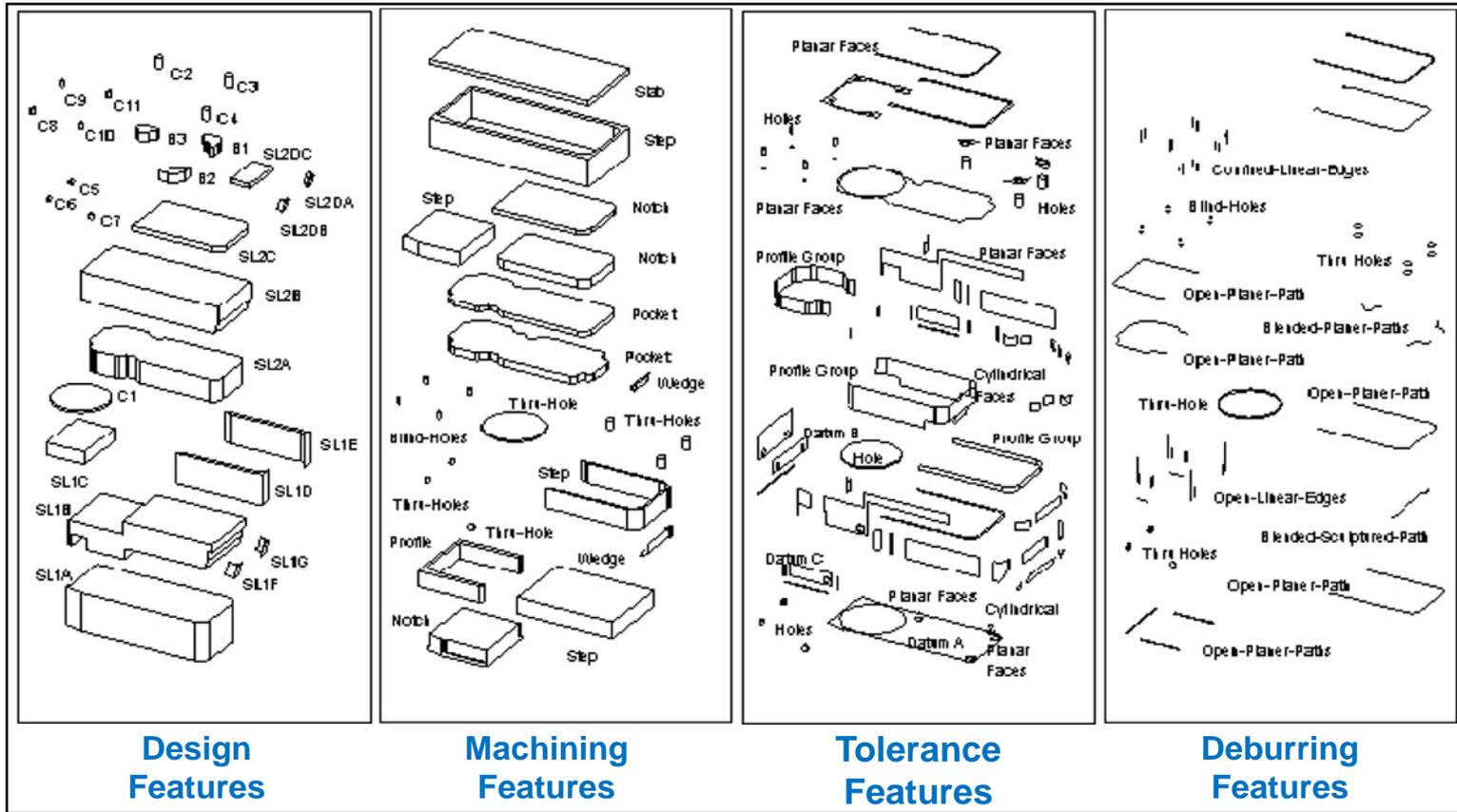
Augmenting Solid Model Shapes With Complete and Unambiguous
Part Tolerances and Other Non-shape Attributes (i.e., Virtual Drawing)

Multiple Perspective of Shape Features



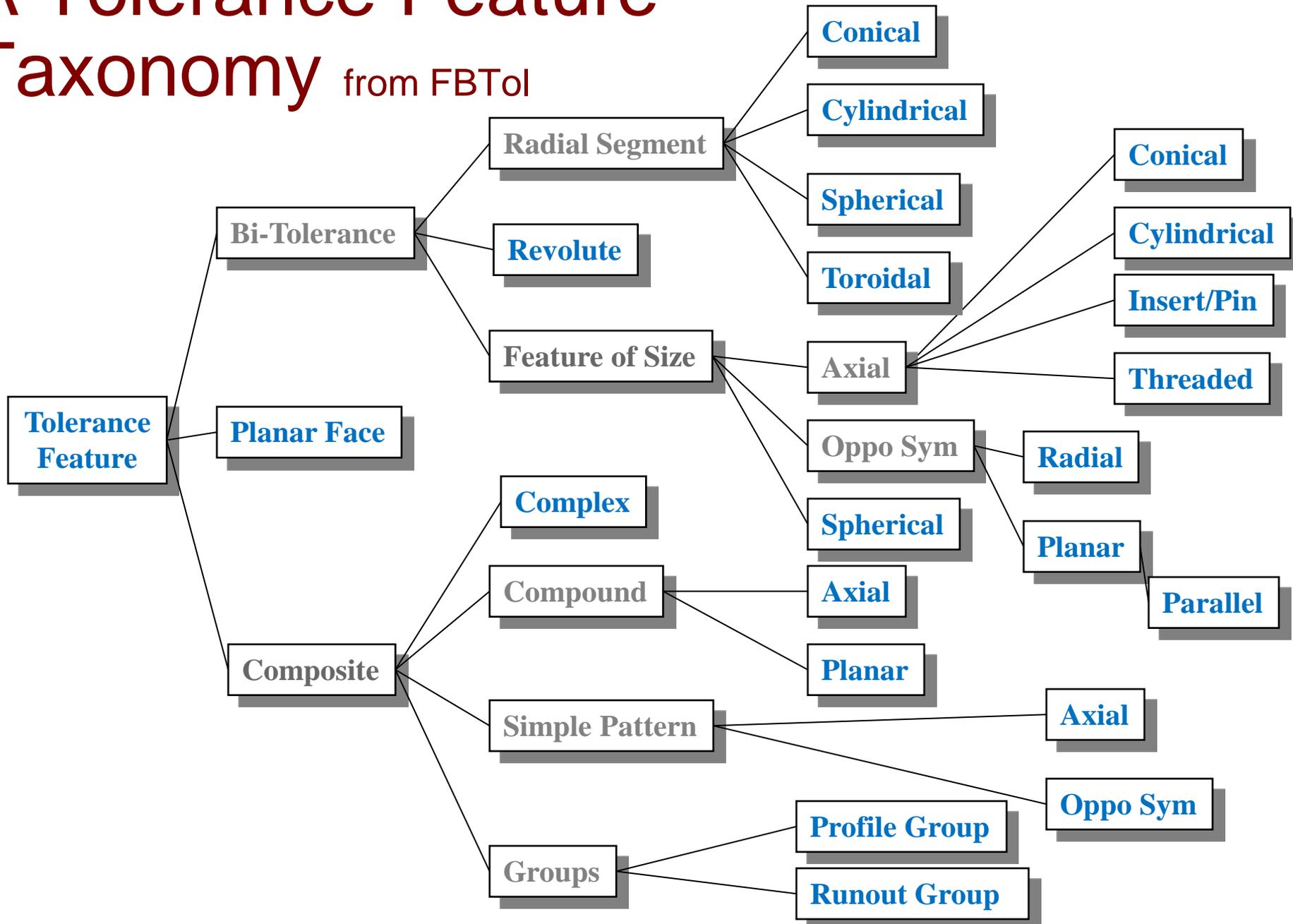
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Multiple Perspective of Shape Features



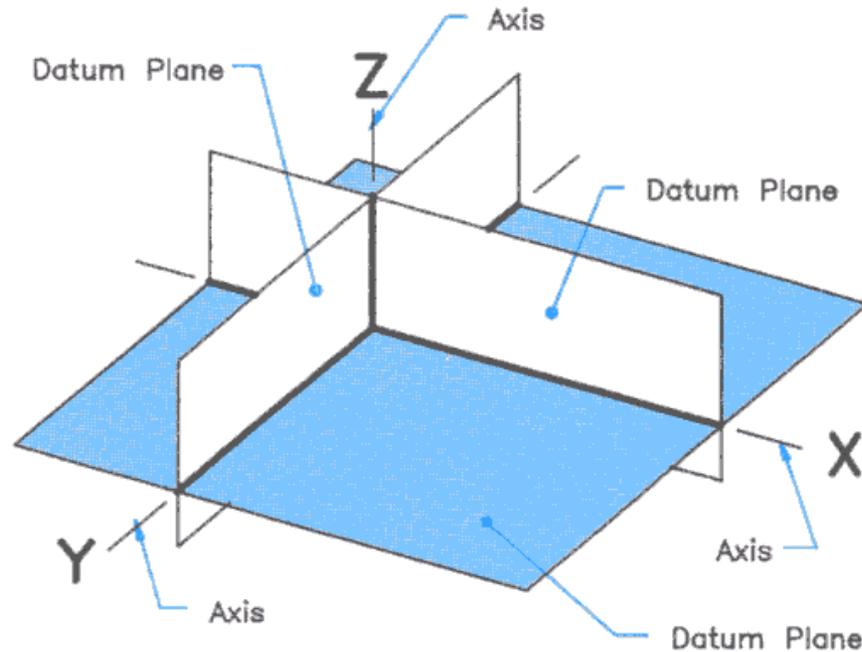
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A Tolerance Feature Taxonomy from FBTol



Datum Reference Frame

A datum reference frame is defined by three mutual perpendicular datum planes.



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Datum Reference Frames

from FBTol



- Presented within a Geometric Tolerance Feature Control Frame
- Defined by One, Two, or Three Datum Features
- Defines Explicit Mathematical Coordinate System
- Constructed from Left to Right Order of Precedence

Datum Reference Frame

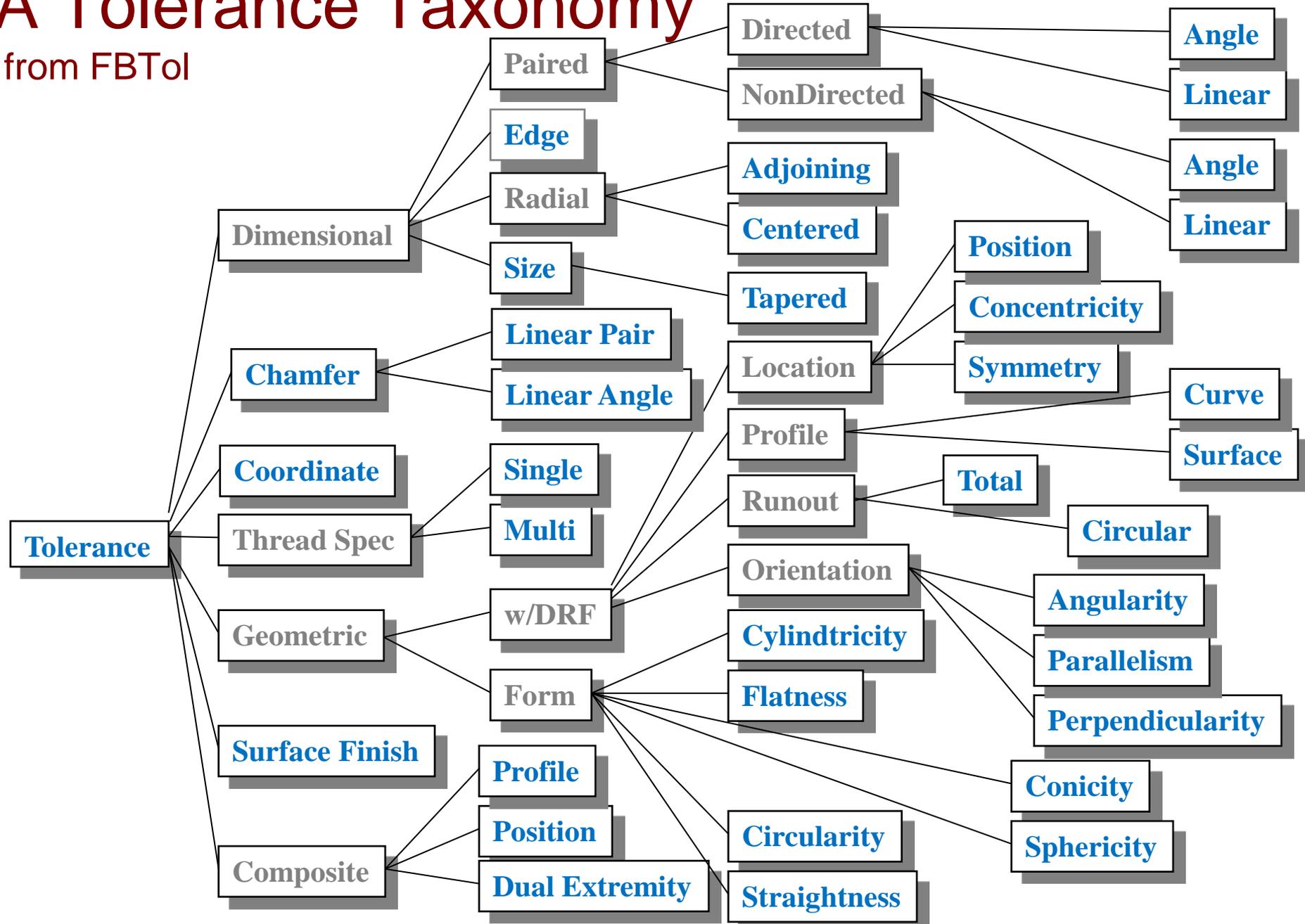
from FBTol



- **Classified per DRF's Datum Feature(s)**
 - Class (e.g., planar, axial, full)
 - Precedence within DRF
 - Geometric Relationship with other Datum Features
 - Simple and Compound Datum Features
 - Extends ASME Y14.5.1M-1994 - DRFs
- **Accommodates Compound Datum Features (e.g., S-T)**
- **Introduces Part Master DRF Concept**

A Tolerance Taxonomy

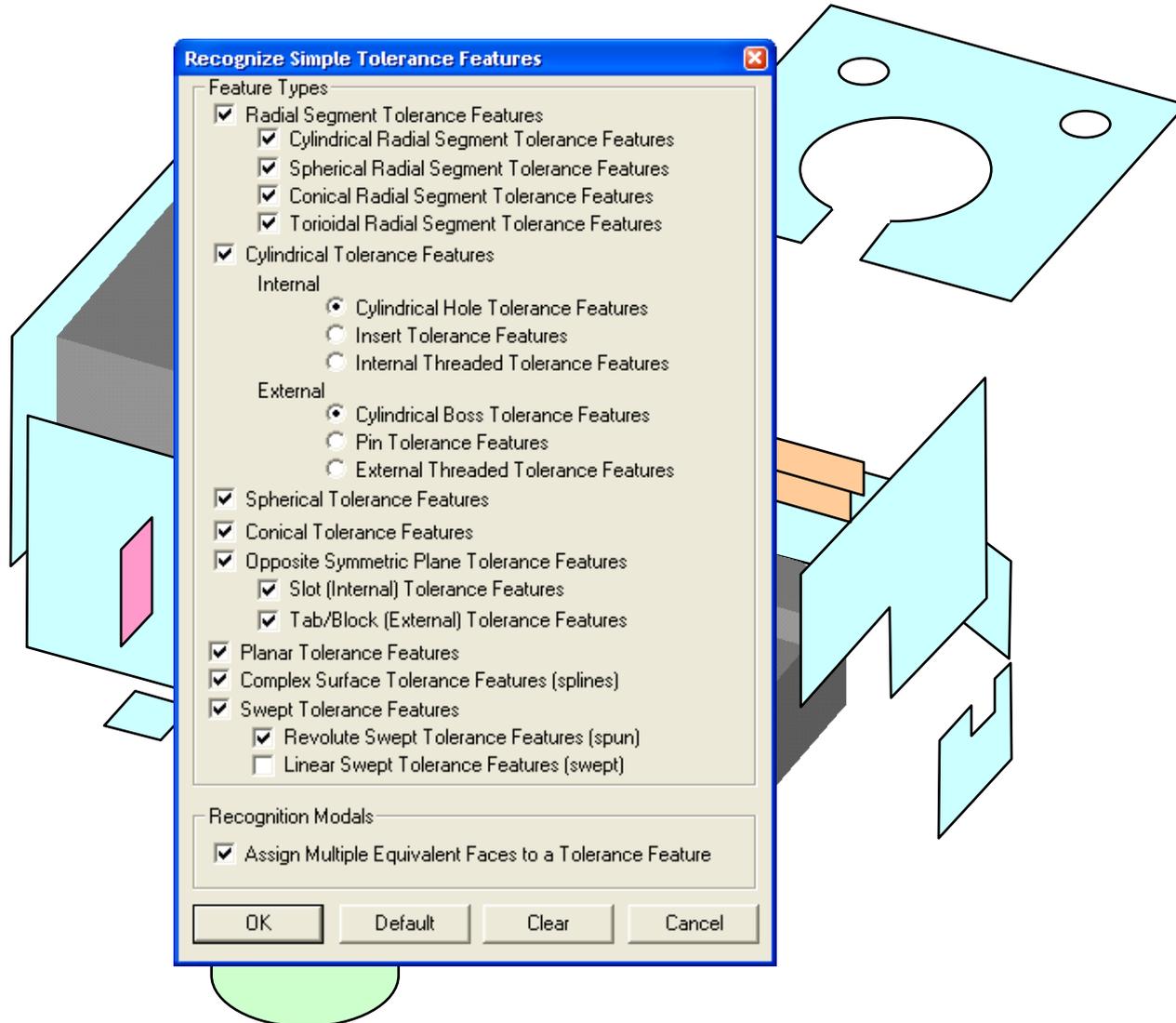
from FBTol



General Property Attribute

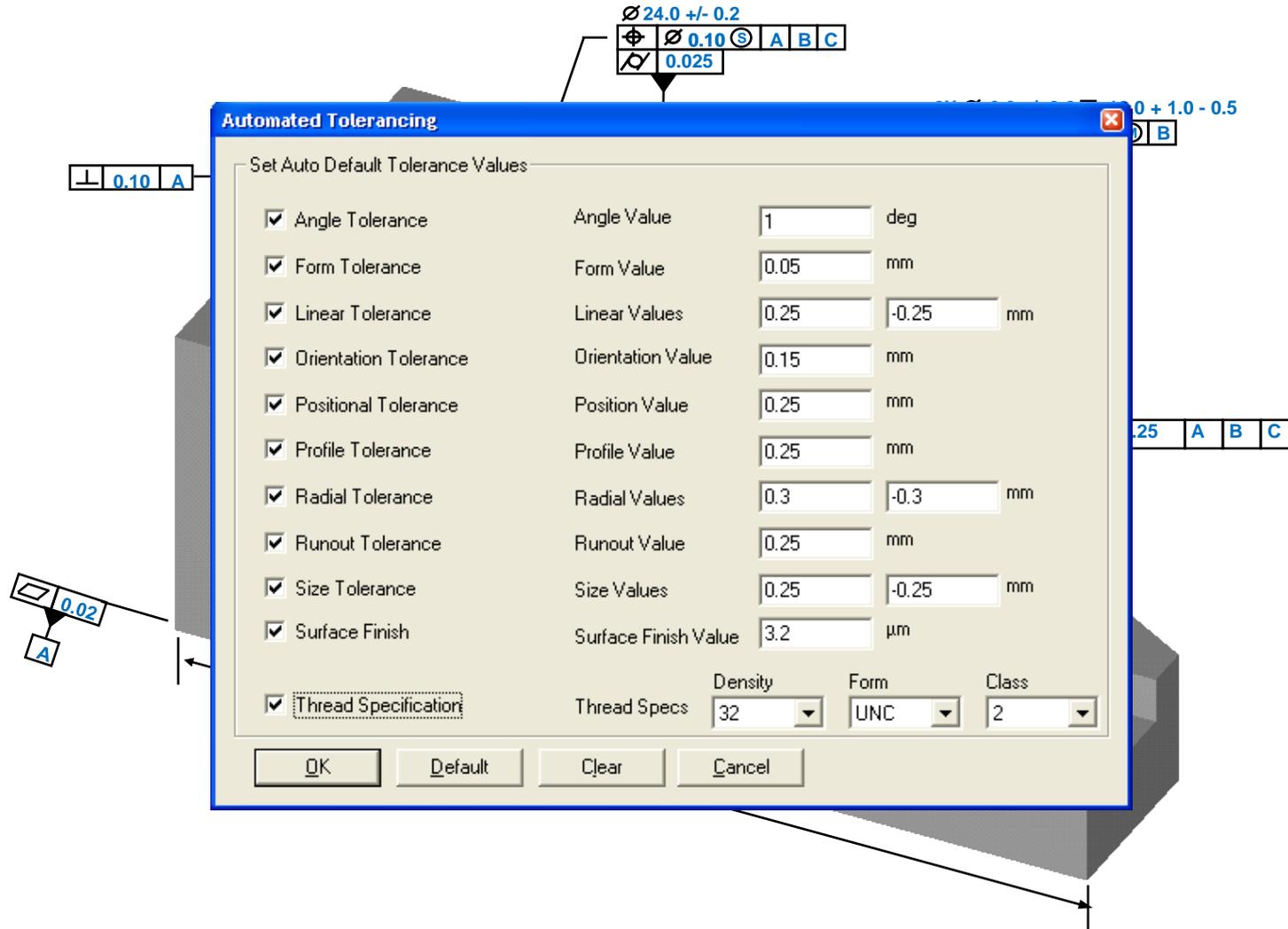
- Notes
- Specifications
- Cosmetic
- Markings
- . . .
- Assign to any entity.

Recognize Tolerance Features



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Infer Correct Product Tolerances



The image shows a 3D model of a part with several tolerance callouts. A central dialog box titled "Automated Tolerancing" is open, displaying default values for various tolerance types. The callouts on the model include: a perpendicularity symbol with 0.10 and A; a circular runout symbol with 0.10, A, B, and C; a circular runout symbol with 0.025; a circular runout symbol with 0.02 and A; a circular runout symbol with 0.10 and B; a circular runout symbol with 0.25, A, B, and C; and a circular runout symbol with 0.10 and B.

Automated Tolerancing

Set Auto Default Tolerance Values

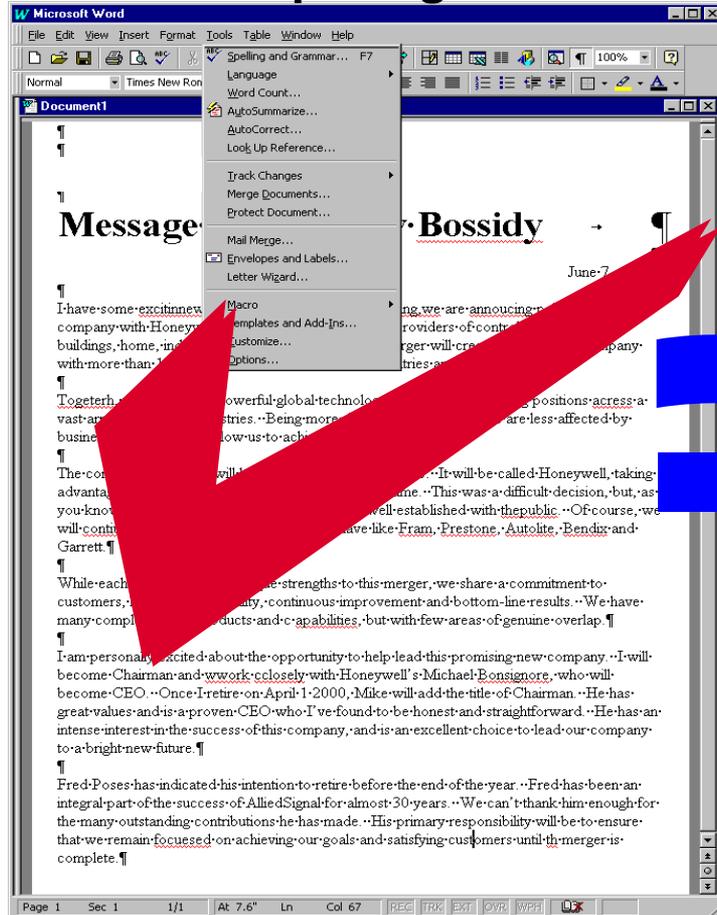
<input checked="" type="checkbox"/> Angle Tolerance	Angle Value	1	deg
<input checked="" type="checkbox"/> Form Tolerance	Form Value	0.05	mm
<input checked="" type="checkbox"/> Linear Tolerance	Linear Values	0.25	-0.25 mm
<input checked="" type="checkbox"/> Orientation Tolerance	Orientation Value	0.15	mm
<input checked="" type="checkbox"/> Positional Tolerance	Position Value	0.25	mm
<input checked="" type="checkbox"/> Profile Tolerance	Profile Value	0.25	mm
<input checked="" type="checkbox"/> Radial Tolerance	Radial Values	0.3	-0.3 mm
<input checked="" type="checkbox"/> Runout Tolerance	Runout Value	0.25	mm
<input checked="" type="checkbox"/> Size Tolerance	Size Values	0.25	-0.25 mm
<input checked="" type="checkbox"/> Surface Finish	Surface Finish Value	3.2	µm
<input checked="" type="checkbox"/> Thread Specification	Thread Specs	Density: 32	Form: UNC, Class: 2

Buttons: **OK** **Default** **Clear** **Cancel**

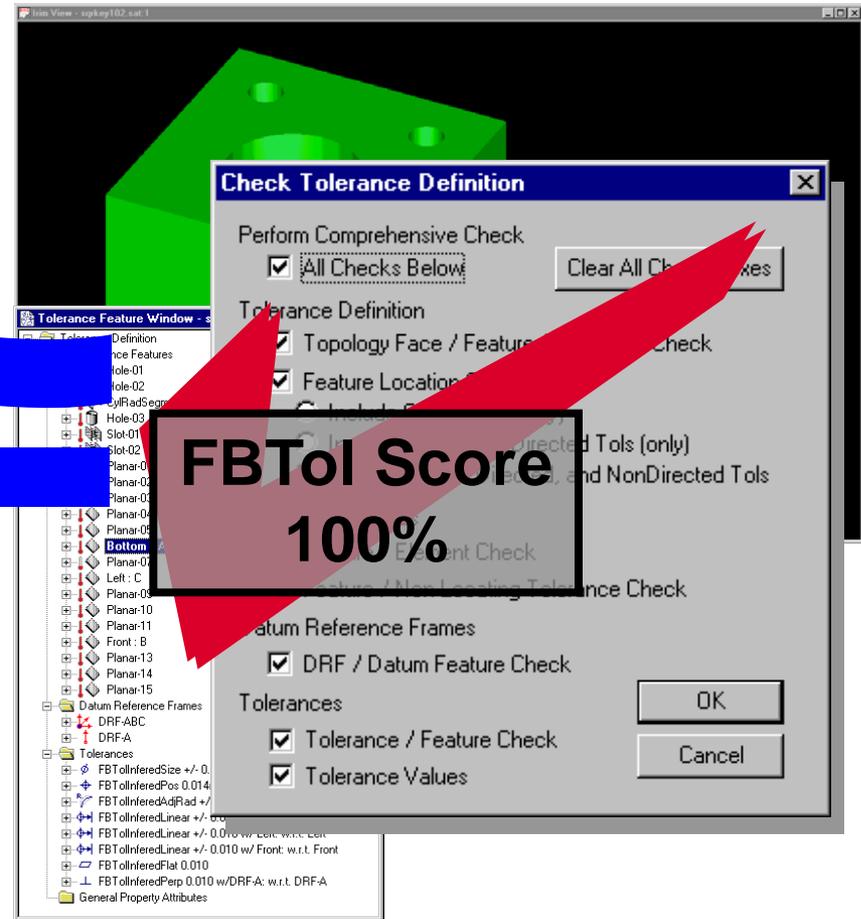
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Check / Score Tolerance Definition

Document Spelling & Grammar



FBTol Tolerance Definition



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Tolerance Definition Review AMBER2



The screenshot displays the SolidWorks 2003 interface for a part named 'AmberTwoFinalIT.SLDPRJT'. The left-hand Feature Tree lists various features, including Planar surfaces (Planar-13 to Planar-22), RidgeBot, RidgeTop, TabsBot, TabsTop, and several radial segments (0.125rInnTorRadSegment-02 to 5.000rInnCyRadSegment-02). The main 3D view shows a dome-shaped component with a red band and green segments. An 'FBTol Advisor GUI' dialog box is open in the foreground, displaying a yellow warning icon and the text: 'Tolerance Definition Check returns with an FBTol Score of 87.0.' with an 'OK' button.



Tolerance Definition Issues

AMBER2

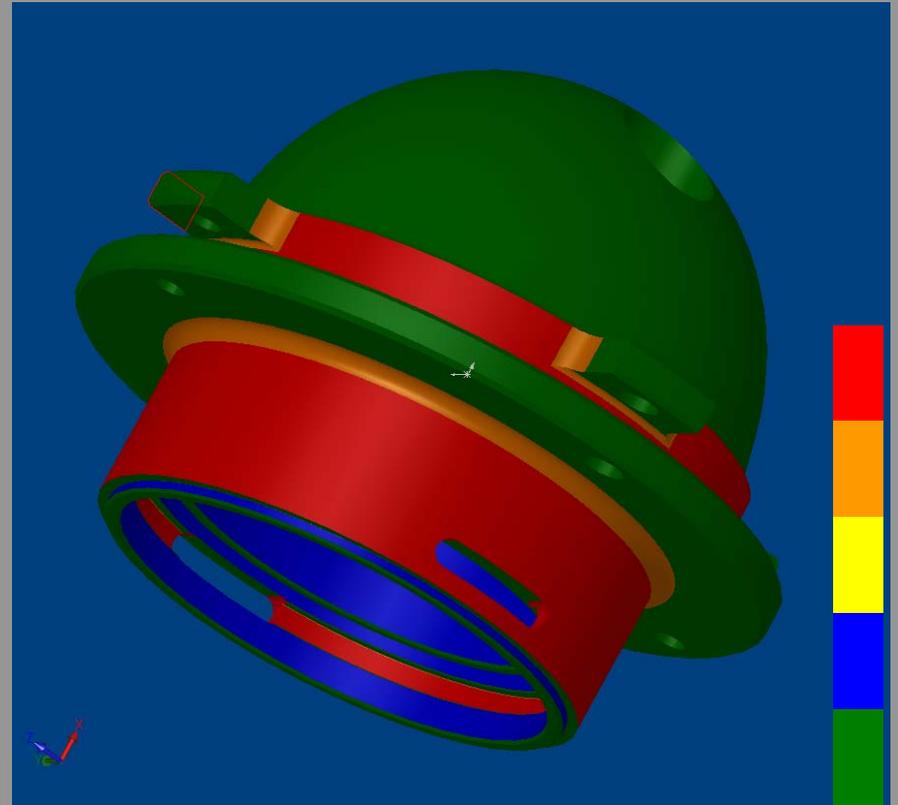
87.0 / 100 FBToI score

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

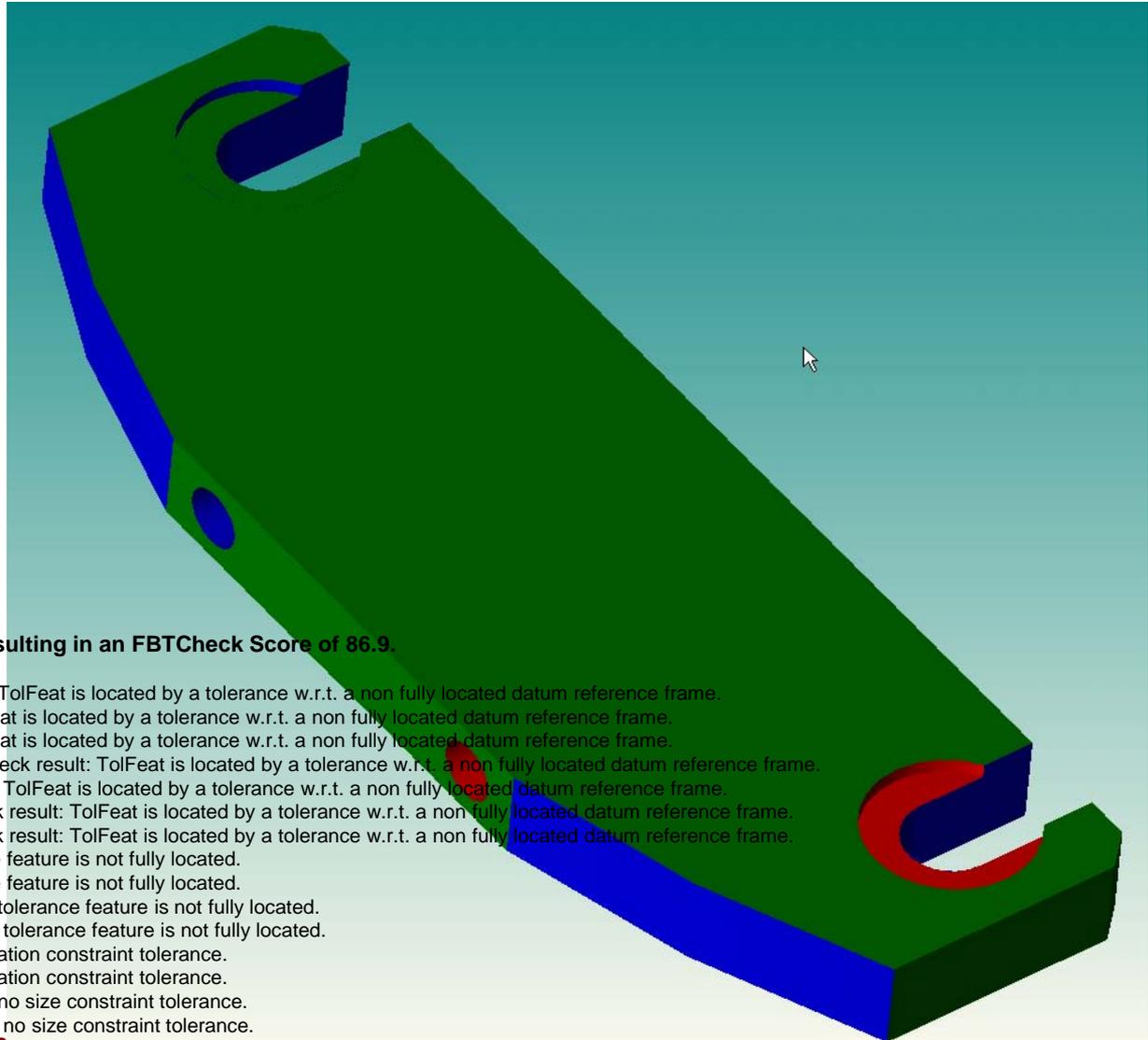
Check result level colors

- 5 **RED** TolFeats.
- 13 **ORANGE** TolFeats.
- 0 **YELLOW** TolFeats.
- 4 **BLUE** TolFeats.
- 49 **GREEN** TolFeats.



FBTol Check Score: 86.9

Lifting Plate



FBTol Check Result Level Summary:

TolDef has 4 RED check result level TolFeats.
TolDef has 0 ORANGE check result level TolFeats.
TolDef has 0 YELLOW check result level TolFeats.
TolDef has 7 BLUE check result level TolFeats.
TolDef has 10 GREEN check result level TolFeats.
TolDef has 0 DK GREEN GRAY suppressed TolFeats.
TolDef has 0 LT GRAY Faces without TolFeats.

FBT CHECK Detail: 15 issues have been identified resulting in an FBTCheck Score of 86.9.

=== FBTCheck Results Begin:

Tolerance Feature: 10.0dIntThread-02 has FBTol Check result: TolFeat is located by a tolerance w.r.t. a non fully located datum reference frame.
Tolerance Feature: 14.1wSlot-01 has FBTol Check result: TolFeat is located by a tolerance w.r.t. a non fully located datum reference frame.
Tolerance Feature: 14.1wSlot-02 has FBTol Check result: TolFeat is located by a tolerance w.r.t. a non fully located datum reference frame.
Tolerance Feature: 205.0rOutCylRadSegment-03 has FBTol Check result: TolFeat is located by a tolerance w.r.t. a non fully located datum reference frame.
Tolerance Feature: 26.0dInnerDiam-01 has FBTol Check result: TolFeat is located by a tolerance w.r.t. a non fully located datum reference frame.
Tolerance Feature: 7.1rInnCylRadSegment-01 has FBTol Check result: TolFeat is located by a tolerance w.r.t. a non fully located datum reference frame.
Tolerance Feature: 7.1rInnCylRadSegment-02 has FBTol Check result: TolFeat is located by a tolerance w.r.t. a non fully located datum reference frame.
Tolerance Feature: Planar-05 has FBTol Check result: tolerance feature is not fully located.
Tolerance Feature: Planar-09 has FBTol Check result: tolerance feature is not fully located.
Tolerance Feature: 10.0dIntThread-01 has FBTol Check result: tolerance feature is not fully located.
Tolerance Feature: 26.0dInnerDiam-02 has FBTol Check result: tolerance feature is not fully located.
Tolerance Feature: Planar-05 has FBTol Check result: no orientation constraint tolerance.
Tolerance Feature: Planar-09 has FBTol Check result: no orientation constraint tolerance.
Tolerance Feature: 10.0dIntThread-01 has FBTol Check result: no size constraint tolerance.
Tolerance Feature: 26.0dInnerDiam-02 has FBTol Check result: no size constraint tolerance.

FBTol Analysis - Housing

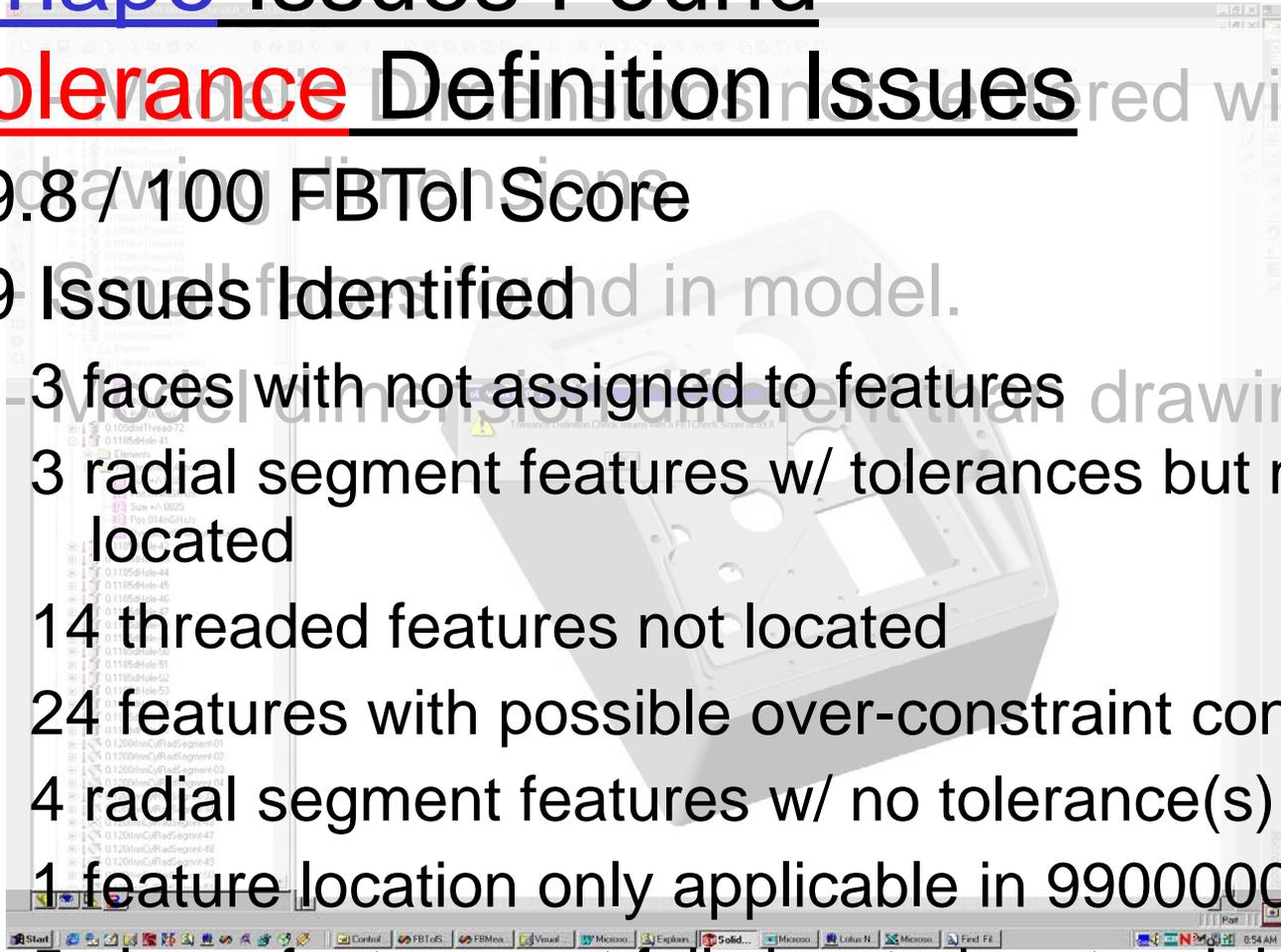
Shape Issues Found

Tolerance Definition Issues

89.8 / 100 FBTol Score

69 Issues Identified

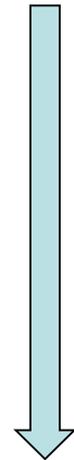
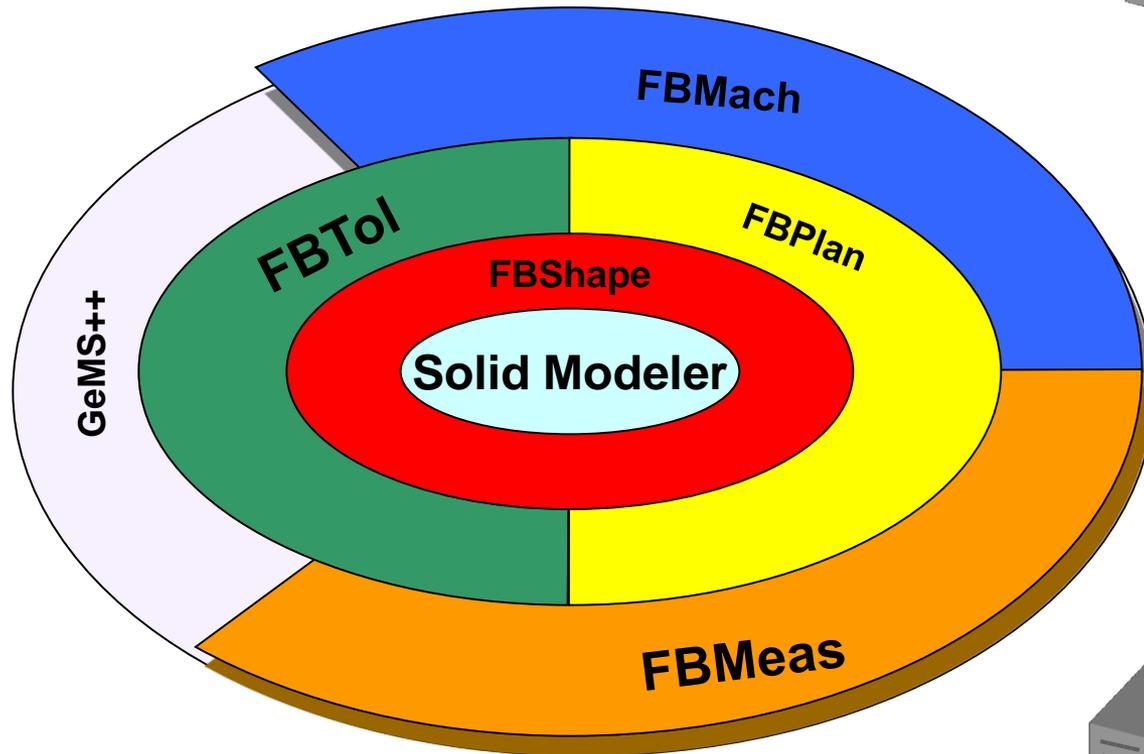
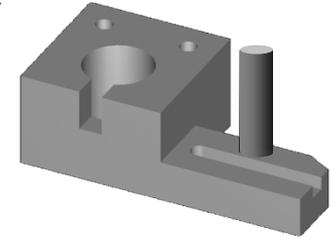
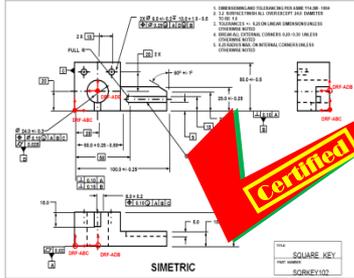
- 1 - 3 faces with not assigned to features
- 3 radial segment features w/ tolerances but not located
- 14 threaded features not located
- 24 features with possible over-constraint condition
- 4 radial segment features w/ no tolerance(s)
- 1 feature location only applicable in 9900000
- 5 planar features not fully located w.r.t. axials
- 4 planar features not located



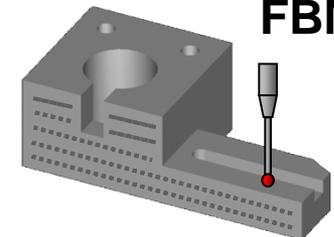
FBTools

Design
w/FBTol

Make



Verify
FBMeas



FBTol enables downstream applications.

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Application Programmers Interface

- Direct Interfaces
- API Interfaces
 - // api_fbt_new_tol_def
 - // api_fbt_create_tol_feat
 - // api_fbt_attach_face_to_tol_feat
 - // api_fbt_get_tolerances_of_tol_feat
 - // api_fbt_check_tol_ent
 - // api_fbt_get_gen_props_of_tol_ent
 - // api_fbt_create_tolerance
 - // api_fbt_attach_tolerance_to_tol_feat
 - // api_fbt_detach_tolerance_from_tol_feat
 - // api_fbt_get_tol_feats_of_tolerance
 - // api_fbt_show_tolerance
 - // api_fbt_get_tol_value
 - // api_fbt_get_or_construct_datum
 - // api_fbt_construct_drf
 - // api_fbt_create_gen_prop_attrib

.....

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FBTol at the KCP

FBTol™ Technology Deployed as:

FBTol™ Advisor standalone, with ACIS & Parasolid solid modelers
Module inside of FBMeas™ Advisor

Reviewed over 175 Production Model / Drawings

Average FBTol score 81.9/100

Average 19.0 issues per analysis

Example: Launch Accelerometer Assembly

FBTol Analyzed 23 Parts in this Assembly

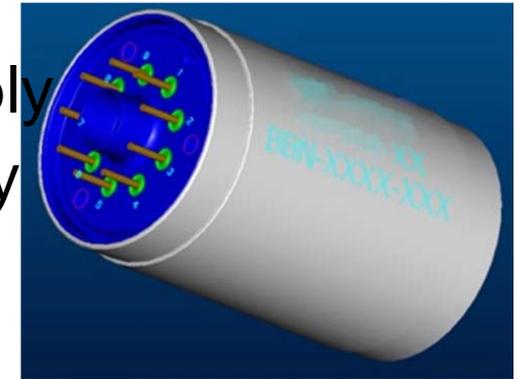
21 parts contained a total of 289 issues

All 52 suggestions where accepted

Modeling Problems Uncovered

Customers more Receptive of Design Input

Considered Best Practice for new Product Programs



FBTol Benefits

- **Product Modeling**
 - Defines the next generation of product definition
- **Tolerance Definition**
 - Creates and represents fully semantic 3D functional tolerances
- **Feature Recognition**
 - Recognizes tolerance features automatically
- **Tolerance Inference**
 - Infers correct tolerances automatically
- **Product Design Validation**
 - Checks and grades piece part tolerance representations
- **Semantics for Display of Annotations**
 - Provides basis for graphical annotations
- **Model-Base Applications**
 - Provides explicit tolerance data for downstream applications
- **Tolerance Data Exchange**
 - Generates and / or validates complete and unambiguous exchange

FBTol - Tactics & Strategies

Max - Min Material Part

Create maximum and least material part from FBTol tolerances

Automated Drawing

Generate drawings from validated FBTol tolerance definition

CAD System Augmentation

Enable CAD systems / applications with smart 3D tolerances

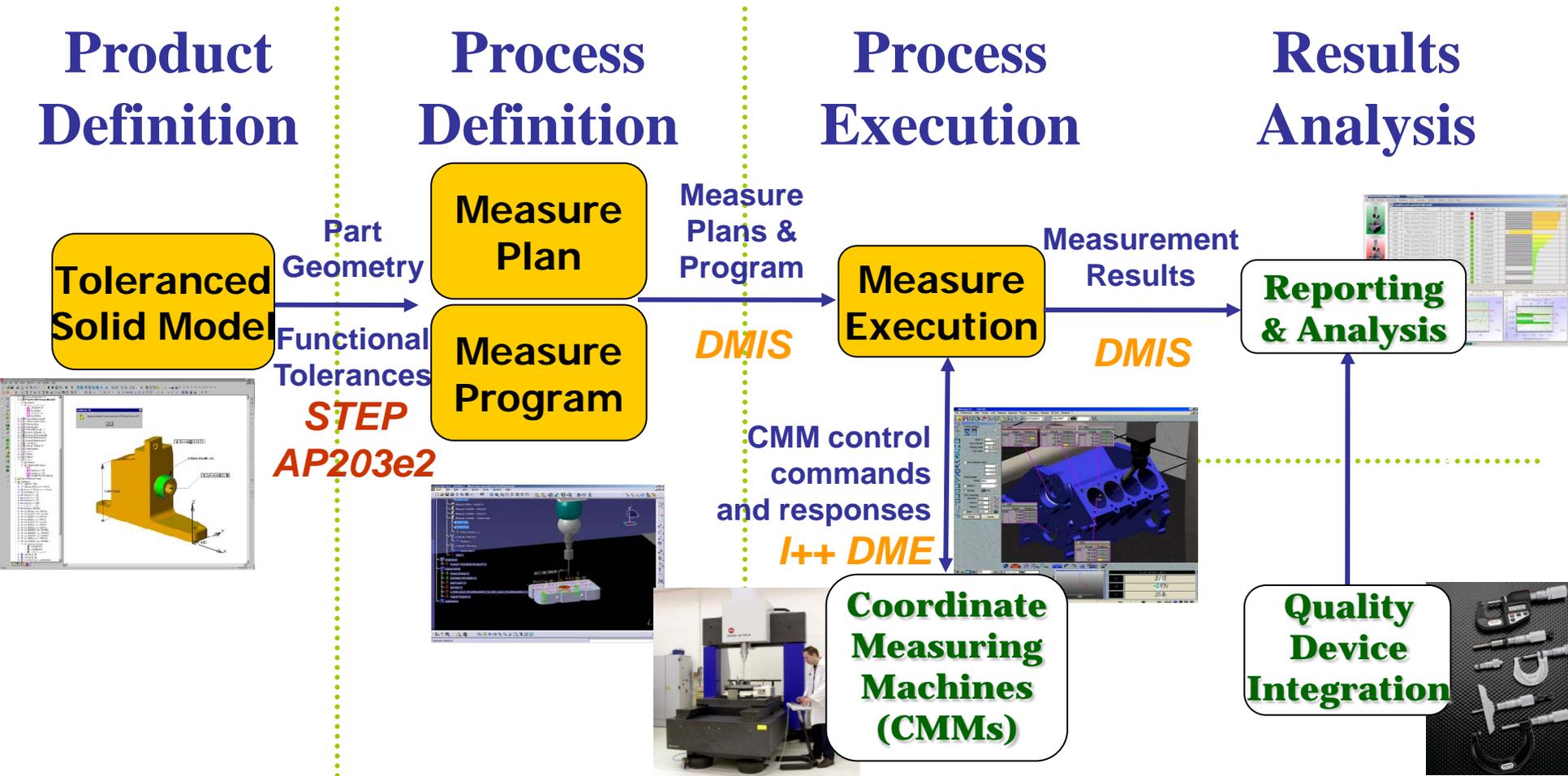
Tolerance Data Exchange

Exchange of tolerance data from system to system (AP203e2, AP242)

Feature-Based Measurement Planning

Use FBTol for model-based measurement planning and auto generation of CMM measurement part programs

Dimensional Metrology Enterprise

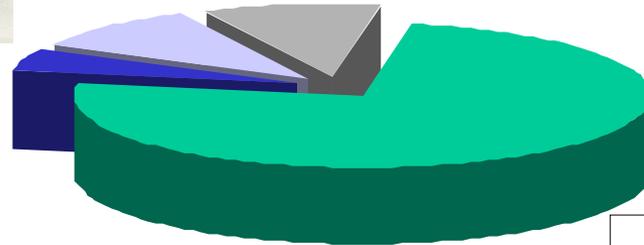


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Coordinate Measurement Cost Budget



**Largest Cost Factor:
CMM Part Programming**



- Part Program Generation
- Measurement Set-Up
- Measurement
- Reporting & Analysis

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Feature-Based Measuring™

a Component Technology for
Measurement Process Planning & Part Program Generation



Transforms Product Requirements (Functional Tolerances) into a
Measurement Action Plan that Produces a Viable ISO Standards-Based
Dimensional Metrology Part Program

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Requirements for Next Generational Measurement Process Planner

Automation:

- ***Full Semantic Representation of Tolerances***
- ***Measure Feature Recognition***
- ***Part Coordinate System Recognition***
- ***Measurand Determination***
- ***Measure Point Generation***
- **DME Resource Selection**
- **Sensor Accessibility Analysis**
- **Workpiece Placement**
- **Sensor Selection & Orientation**
- **Measurement Plan Inference**
- **Measurement Plan Centric**
- **Inter & Intra Feature Clearance Moves**
- ***Measurement Part Program Output (ISO DMIS)***

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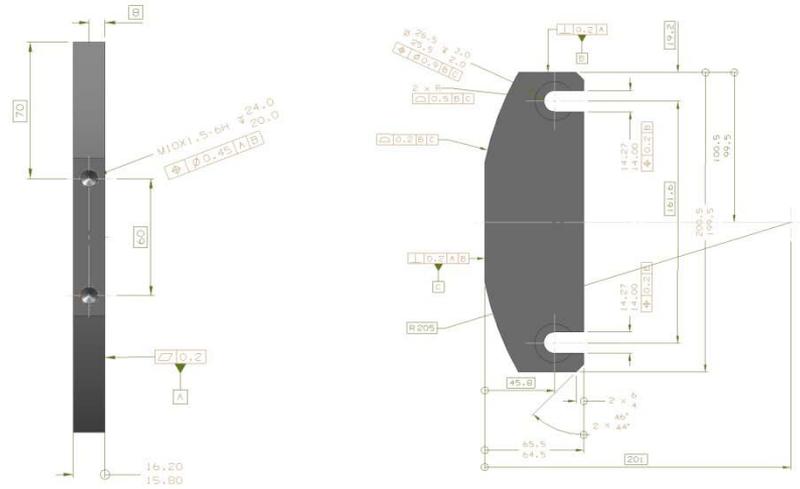
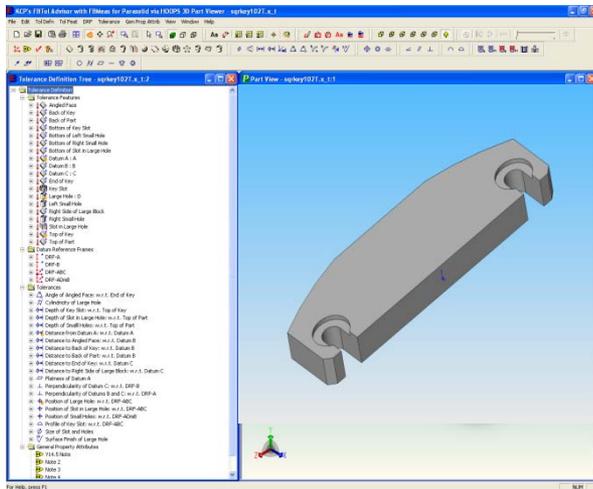
Feature-Based Measuring

Solid Modeler Kernel (Parasolid, ACIS) Feature-Based Tolerancing (FBTol) Advisor Feature-Based Measuring (FBMeas) Advisor

- From Tolerances, Auto Recognize Measure Features, Part Coordinate Systems, Measurands
- Distribution PtMeas
- Determine Resources (Sensors, CMMs)
- Generate CMM Measure Plan
- Output ISO DMIS Part Program

Demonstration

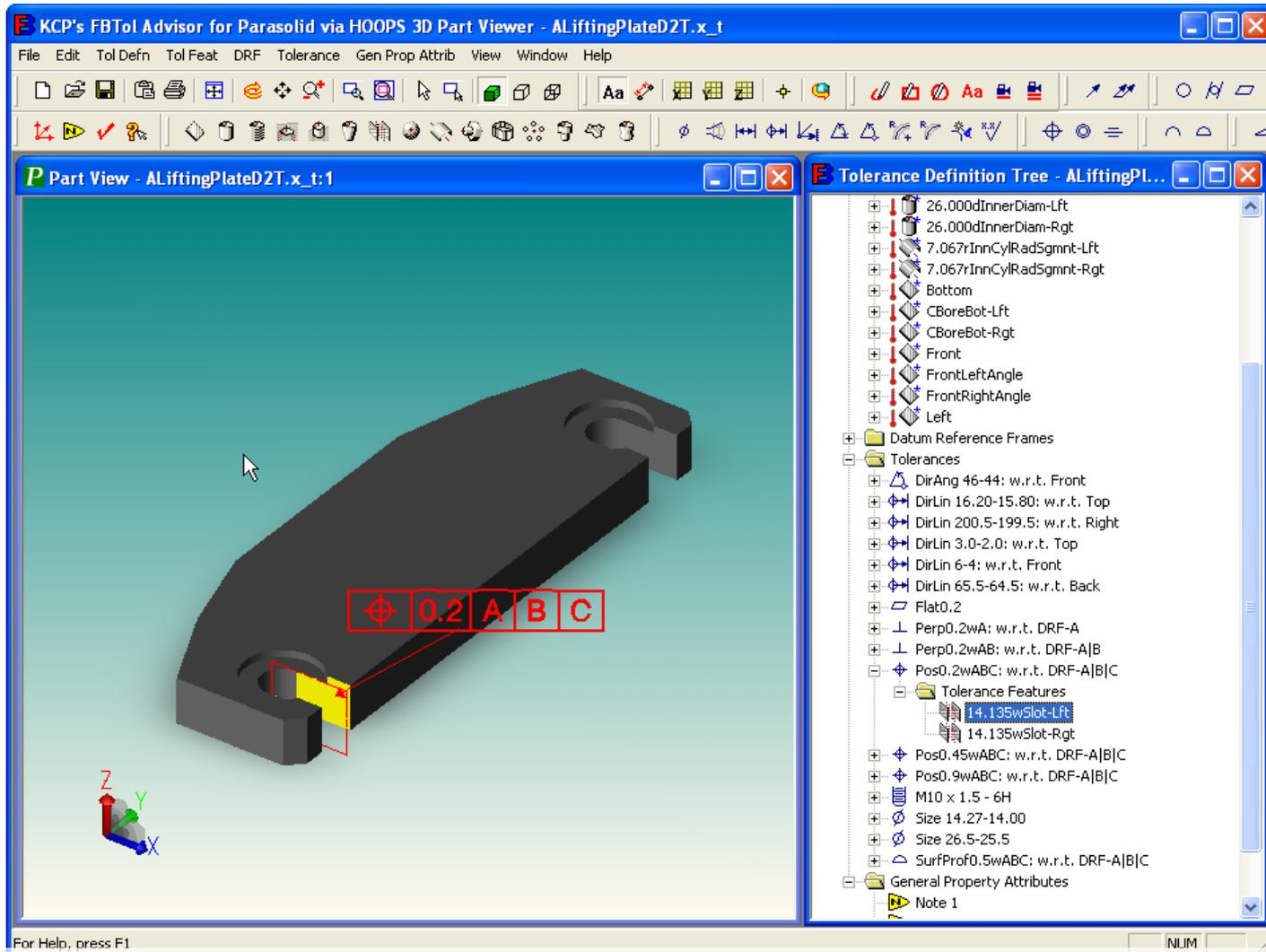
From a Solid Model
to a Full-Semantic Toleranced Solid Model
to a Validated Tolerance Definition
to a Measurement Process Plan
to a CMM Part Program



...Model to Plan to Program in 10 Minutes

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Fly-By Demonstration



[Click for FBToI/FBMeas LiftingPlate Demo Video – by Curtis Brown](#)
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National Security

The screenshot displays the FBMeasGui software interface, titled "Scheme 1". The main window is divided into several panes:

- Tolerance Definition Tree:** Lists various tolerance features such as Datum Reference Frames (DRF-ABC, DRF-ADmB, DRF-A, DRF-B), Tolerances (Flat0.02, Cyl0.025, Size +/- 0.2, etc.), and General Property Attributes.
- Part View - Sqrkey102aTM:1:** Shows a 3D model of a mechanical part, colored green and red, with a central hole and a slot.
- Measuring Definition Tree Window - Sqrkey102aTM:1:** Lists measuring features including Measure Features (2.5rOutCylRadSegment-01M, 6.0dHole-01M, etc.), Elements, Datum Reference Frames, Tolerances, and Measure Task Group (General Measure Task - 1, Coord Metrology Method, Point Measures).
- Scheme Window - Scheme1:** Displays the following text:

```
MEASURE FEATURE Description Started for:  
Name: FrontM Type: PlnMF  
FEATURE ELEMENTS:  
  Topology:  
  Face: Face-21 Type: Planar  
GEOMETRY:  
  Location: x:150.000000 y:100.000000 z:7.500000  
  Normal: i:0.000000 j:-1.000000 k:0.000000  
  Surface Area: 2342.500000  
Used to help measure Tolerance Feature: Front Type: Pln  
TOLERANCES:  
Measure Feature is controlled by 3 tolerances.  
Size Tolerance(s): none  
Locating Tolerance(s): none
```

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FBMeasGui - Scheme1

File Edit View Window Help

Tolerance Definition Tree - Sqrkey102aTM:1

- Tolerance Definition
 - Tolerance Features
 - 2.5rOutCylRadSegment-01
 - 6.0dHole-01
 - 6.0dHole-02
 - 24.0dHole-03 : D
 - 8.0wSlot-02
 - KeyShaftEnd
 - Bottom : A
 - KeyShaftAngle
 - KeyShaftTop
 - Bot3EntProfGroup
 - Bot6.0dHoles
 - Top
 - BotSlot
 - Front : B
 - Back
 - Right
 - KeyShaftBack
 - Left : C
 - 3EntProfileGroup-01
 - Datum Reference Frames
 - DRF-ABC
 - DRF-AdmB
 - DRF-A
 - DRF-B
 - Tolerances
 - Flat0.02
 - Cyl0.025
 - Size +/- 0.2
 - Pos0.10sABC: w.r.t. DRF-AI
 - Pos0.25mAdmB: w.r.t. DRF-
 - SurfProf0.25ABC: w.r.t. DR
 - Perp0.10A: w.r.t. DRF-A
 - Perp0.15B: w.r.t. DRF-B
 - NonDirLin +/- 0.25

Part View - Sqrkey102aTM:1

Measuring Definition Tree Window - Sqrkey102aTM:1

- Measuring Definition
 - Measure Features
 - 2.5rOutCylRadSegment-01M
 - 6.0dHole-01M
 - 6.0dHole-02M
 - 24.0dHole-03M : D
 - 8.0wSlot-02M
 - KeyShaftEndM
 - BottomM : A
 - KeyShaftAngleM
 - KeyShaftTopM
 - Bot3EntProfGroupM
 - Bot6.0dHolesM
 - TopM
 - BotSlotM
 - FrontM : B
 - Elements
 - Datum Reference Frames
 - Tolerances
 - Measure Task Group
 - General Measure Task - 1
 - Coord Metrology Method
 - Point Measures
 - PtMeas: 102.000, 100.000, 33.000
 - PtMeas: 133.167, 100.000, 33.000
 - PtMeas: 102.000, 100.000, 22.667
 - PtMeas: 133.167, 100.000, 22.667
 - PtMeas: 102.000, 100.000, 12.333
 - PtMeas: 133.167, 100.000, 12.333
 - PtMeas: 164.333, 100.000, 12.333
 - PtMeas: 195.500, 100.000, 12.333
 - PtMeas: 102.000, 100.000, 2.000
 - PtMeas: 133.167, 100.000, 2.000
 - PtMeas: 164.333, 100.000, 2.000
 - PtMeas: 195.500, 100.000, 2.000
 - BackM
 - RightM
 - KeyShaftBackM
 - LeftM : C
 - 3EntProfileGroup-01MFace7
 - 3EntProfileGroup-01MFace10
 - 3EntProfileGroup-01MFace11
- Part Coordinate Systems
 - PCS-ABC
 - PCS-ADB
- Sensor Definitions
 - Fixed01
 - Fixed02
 - Fixed03
 - PH10M

Scheme Window - Scheme1

Measure Method Description Started for: DME Measurement Method: Coord Metrology Method

Sensor Tip: ITip0101 Type: Spherical with Diameter: 2.000

Master Sensor of Sensor Config: PH10M at Tilt Angle: 0.00 and Rot Angle: 90.00

Assigned to DME Method: Coord Metrology Method

Sensor Tip: ITip0101 Type: Spherical with Diameter: 2.000

Master Sensor of Sensor Config: PH10M at Tilt Angle: 0.00 and Rot Angle: 90.00

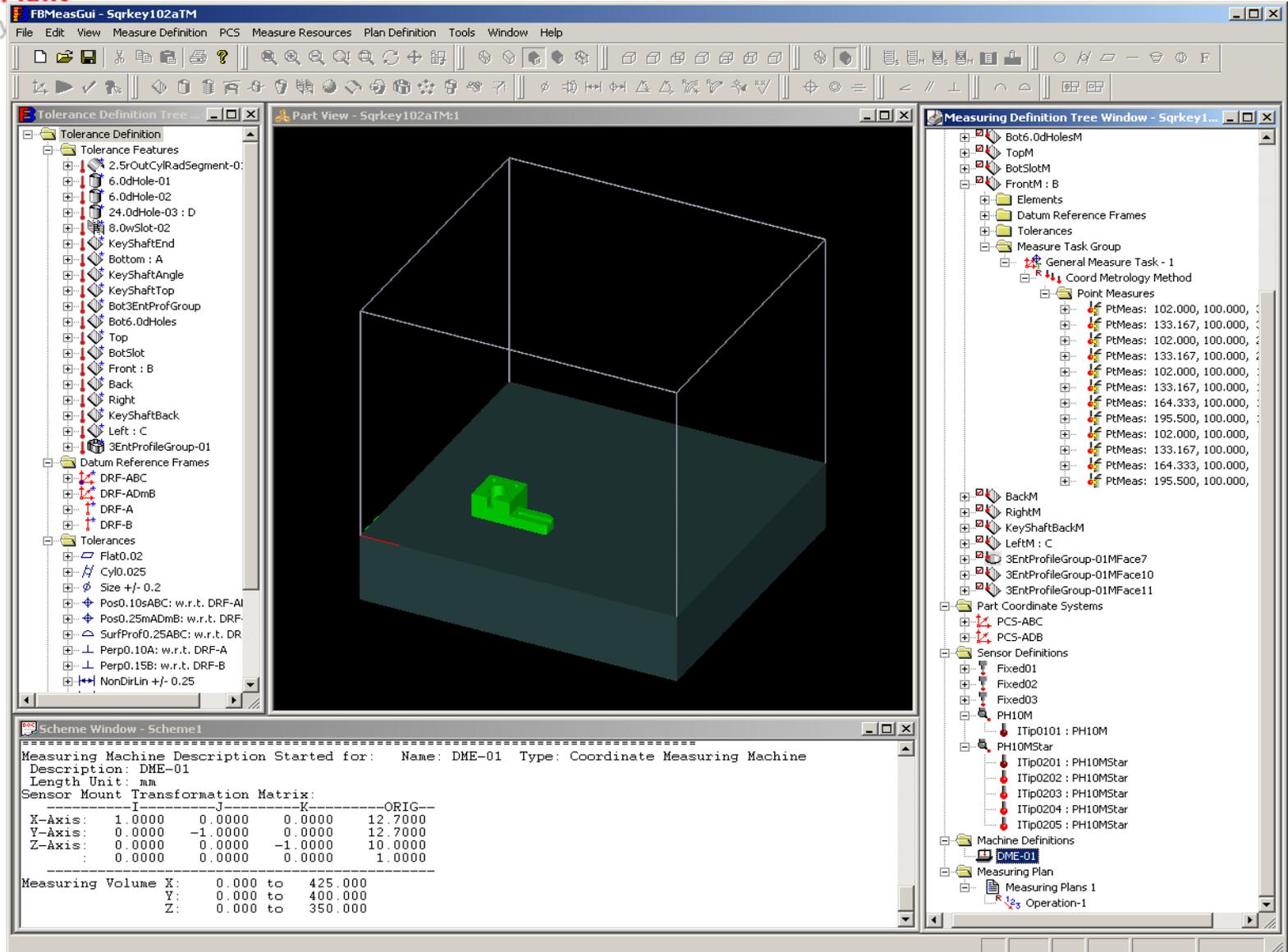
Assigned to DME Method: Coord Metrology Method

Point Measures:

- PtMeas- 1: x: 100.500, y: 100.000, z: 34.500, i: 0.000, j: -1.000, k: 0.000
- Sensor Tip: ITip0101 with Sensor Config: PH10M at Tilt Angle: 0.00 and Rot Angle: 90.00
- PtMeas- 2: x: 132.667, y: 100.000, z: 34.500, i: 0.000, j: -1.000, k: 0.000
- Sensor Tip: ITip0101 with Sensor Config: PH10M at Tilt Angle: 0.00 and Rot Angle: 90.00
- PtMeas- 3: x: 100.500, y: 100.000, z: 23.167, i: 0.000, j: -1.000, k: 0.000
- Sensor Tip: ITip0101 with Sensor Config: PH10M at Tilt Angle: 0.00 and Rot Angle: 90.00

For Help, press F1

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FBMeasGui - Sqrkey102aTM

File Edit View Measure Definition PCS Measure Resources Plan Definition Tools Window Help

Tolerance Definition Tree

- Tolerance Definition
 - Tolerance Features
 - 2.5rOutCyRadSegment-0:
 - 6.0dHole-01
 - 6.0dHole-02
 - 24.0dHole-03 : D
 - 8.0wSlot-02
 - KeyShaftEnd
 - Bottom : A
 - KeyShaftAngle
 - KeyShaftTop
 - Bot3EntProfGroup
 - Bot6.0dHoles
 - Top
 - BotSlot
 - Front : B
 - Back
 - Right
 - KeyShaftBack
 - Left : C
 - 3EntProfileGroup-01
 - Datum Reference Frames
 - DRF-ABC
 - DRF-ADmB
 - DRF-A
 - DRF-B
 - Tolerances
 - Flat0.02
 - Cyl0.025
 - Size +/- 0.2
 - Pos0.10sABC: w.r.t. DRF-AI
 - Pos0.25mADmB: w.r.t. DRF-
 - SurfProf0.25ABC: w.r.t. DR
 - Perp0.10A: w.r.t. DRF-A
 - Perp0.15B: w.r.t. DRF-B
 - NonDirLin +/- 0.25

Part View - Sqrkey102aTM:1

Measuring Definition Tree Window - Sqrkey1...

- Bot6.0dHolesM
 - TopM
 - BotSlotM
 - FrontM : B
 - Elements
 - Datum Reference Frames
 - Tolerances
 - Measure Task Group
 - General Measure Task - 1
 - Coord Metrology Method
 - Point Measures
 - PtMeas: 102.000, 100.000, 0.000
 - PtMeas: 133.167, 100.000, 0.000
 - PtMeas: 102.000, 100.000, 0.000
 - PtMeas: 133.167, 100.000, 0.000
 - PtMeas: 102.000, 100.000, 0.000
 - PtMeas: 133.167, 100.000, 0.000
 - PtMeas: 164.333, 100.000, 0.000
 - PtMeas: 195.500, 100.000, 0.000
 - PtMeas: 102.000, 100.000, 0.000
 - PtMeas: 133.167, 100.000, 0.000
 - PtMeas: 164.333, 100.000, 0.000
 - PtMeas: 195.500, 100.000, 0.000
 - BackM
 - RightM
 - KeyShaftBackM
 - LeftM : C
 - 3EntProfileGroup-01MFace7
 - 3EntProfileGroup-01MFace10
 - 3EntProfileGroup-01MFace11
- Part Coordinate Systems
 - PCS-ABC
 - PCS-ADB
- Sensor Definitions
 - Fixed01
 - Fixed02
 - Fixed03
 - PH10M
 - ITip0101 : PH10M
 - PH10MStar
 - ITip0201 : PH10MStar
 - ITip0202 : PH10MStar
 - ITip0203 : PH10MStar
 - ITip0204 : PH10MStar
 - ITip0205 : PH10MStar
- Machine Definitions
 - DME-01
 - Measuring Plan
 - Measuring Plans 1
 - Operation-1

Scheme Window - Scheme1

Measuring Machine Description Started for: Name: DME-01 Type: Coordinate Measuring Machine
Description: DME-01
Length Unit: mm

Sensor Mount Transformation Matrix:

	I	J	K	ORIG
X-Axis:	1.0000	0.0000	0.0000	12.7000
Y-Axis:	0.0000	-1.0000	0.0000	12.7000
Z-Axis:	0.0000	0.0000	-1.0000	10.0000
	0.0000	0.0000	0.0000	1.0000

Measuring Volume X: 0.000 to 425.000
Y: 0.000 to 400.000
Z: 0.000 to 350.000

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Working with the KCP

Partnering Mechanisms:

- ***Work for Others (WFO)*** Contract services from the KCP as cost recovery only.
- ***Cooperative Research & Development Agreement (CRADA)*** KCP and partner collaborate in creating new Intellectual Property
- ***Licensing KCP Intellectual Property*** for the purpose of maturation and commercialization of KCP technologies.

Way Forward:

- ***Progress Shared Agendas*** – Mandates NNSA (KCP) invented technology be transferred to the benefit of the US economy and/or US industry.

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Summary

■ Feature-Based Tolerancing

- Manages the complexity of ASME Y14.5 GD&T of piece parts.
- Represents and checks part designs per standards.
- Enables next generation (smarter) automation.
- Could be integrated into a leading CAD system with the appropriate partnering.

■ Feature-Based Measuring

- Manages the complexity of rapidly generating valid CMM part program to dimensionally certify products.
- Demonstrates a next generation manufacturing application from toleranced enable solid models
- Functional prototype that could be extended/enhanced with partners.

■ Partnering

- Collaborate a common agenda
- Progress your agenda

Questions?

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