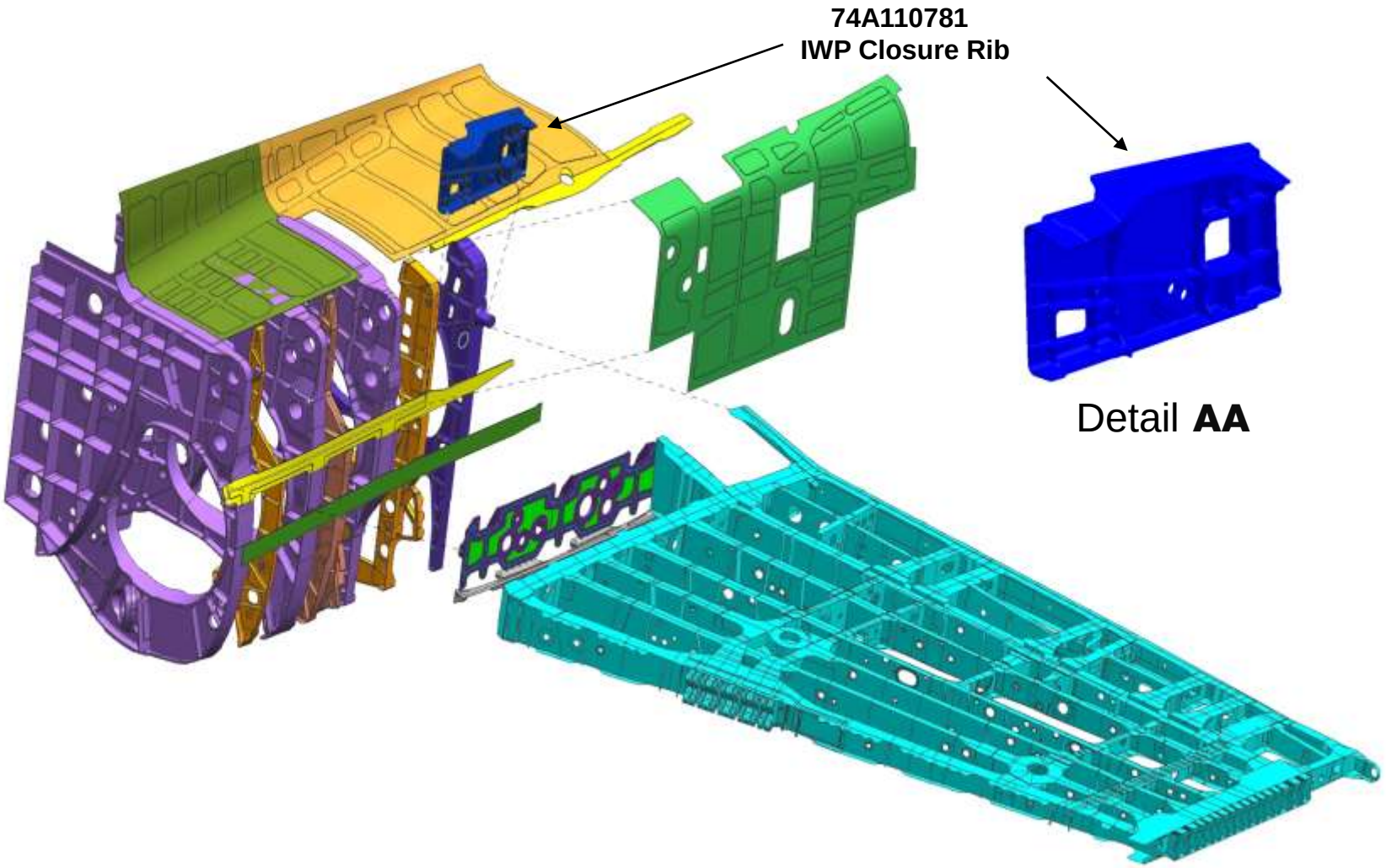
NAVAIR
Non Contact In-Process Inspection

Gabe Draguicevich
N42 FRC-SW
NAVAIR NI
Aug 25th, 2015

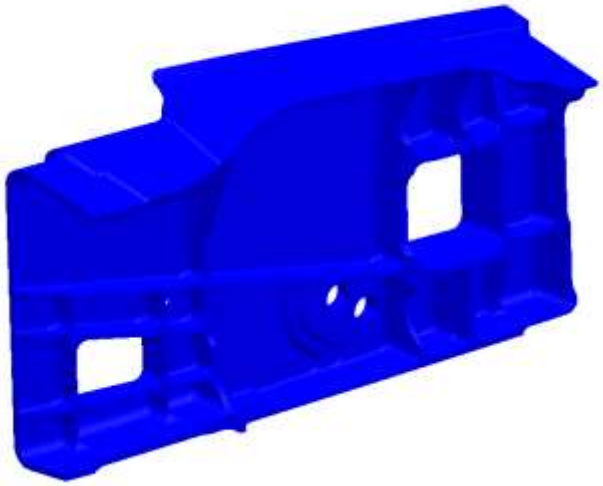
Overview

- Background on Navy 3D Model Status
  - (3MS / MBD)
- Proposed System Examples
- Definition of Digital Product Definition and Model-Based Definition (MBD)
- Model-Based GD&T for Inspection
- Challenges
- Resources

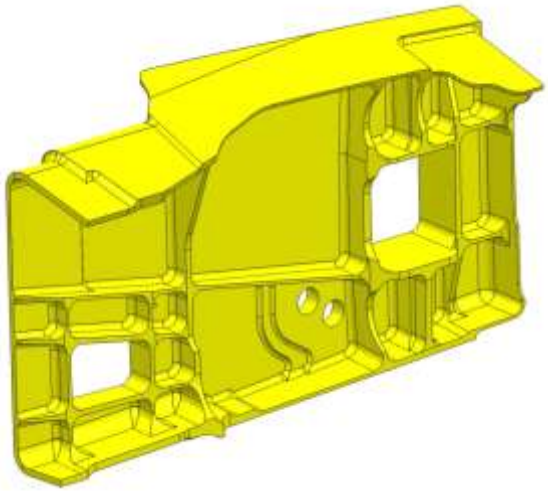
F/A-18 IWP CLOSURE RIB



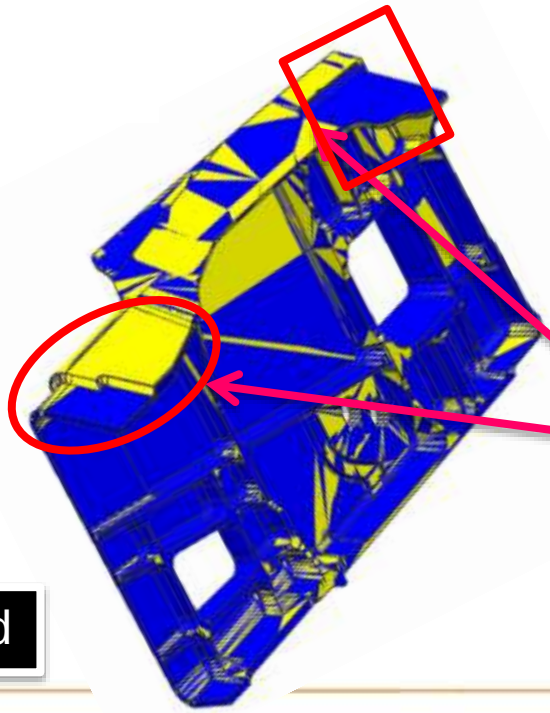
CLOSURE RIB COMPARAISON



Part from 2D Blue Print



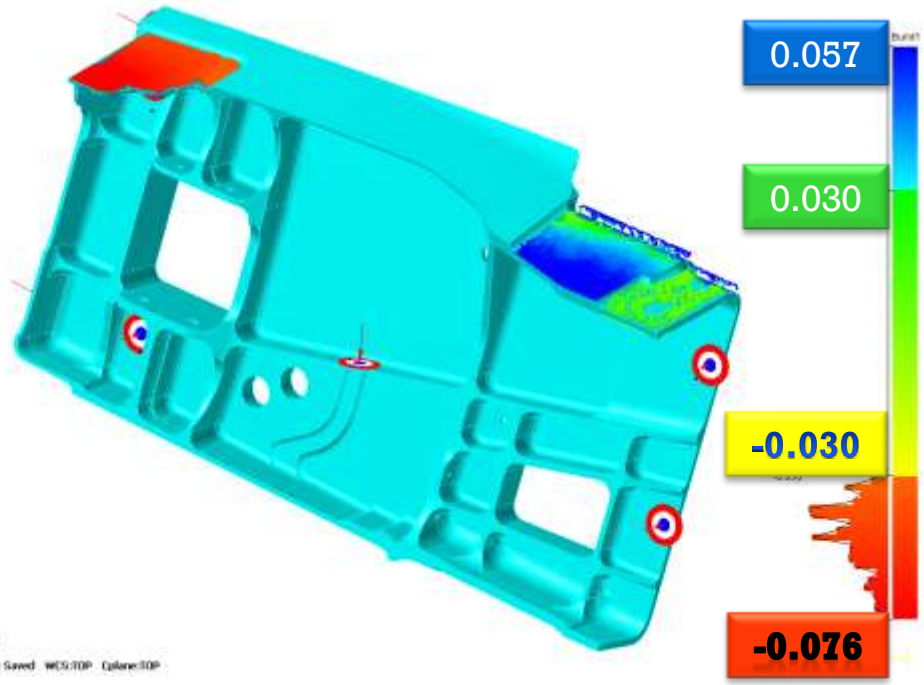
Scanned Part from Aircraft

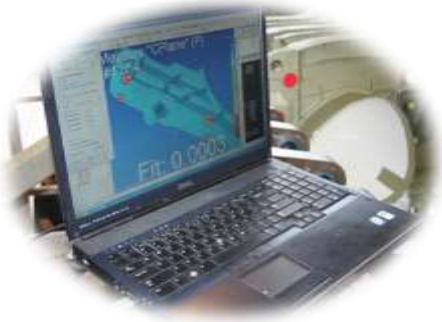


Areas of Interest

Part Superimposed

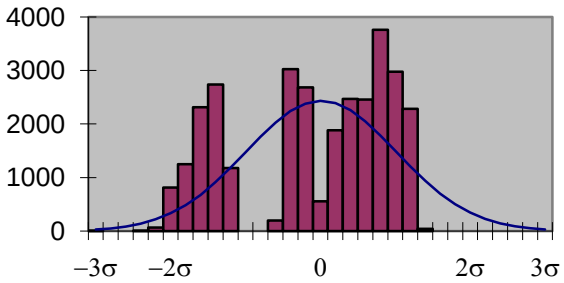
CLOSURE RIB ADVANCED MEASUREMENT



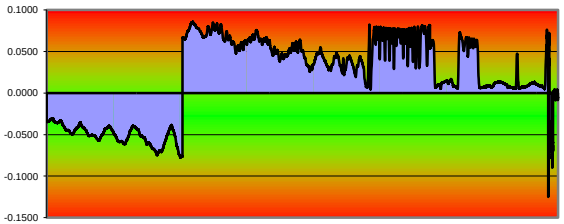


Verisurf Build

FaroArm®

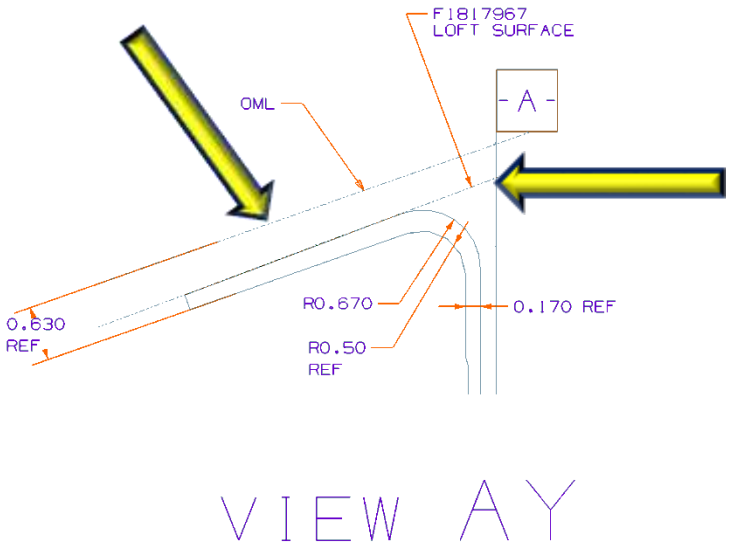


Bell Curve 6σ

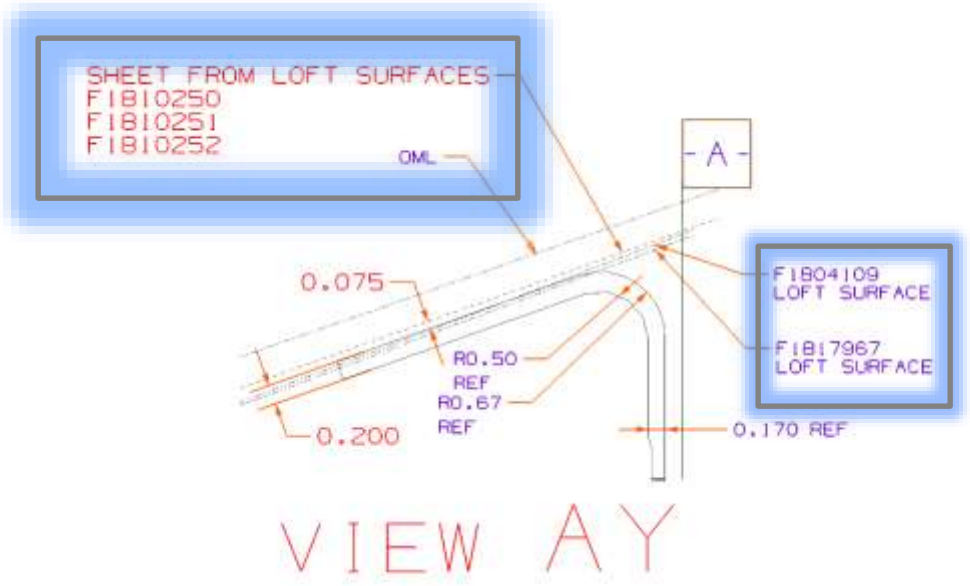


Model Deviation Graph

CLOSURE RIB ML DEFINITION PER B/P

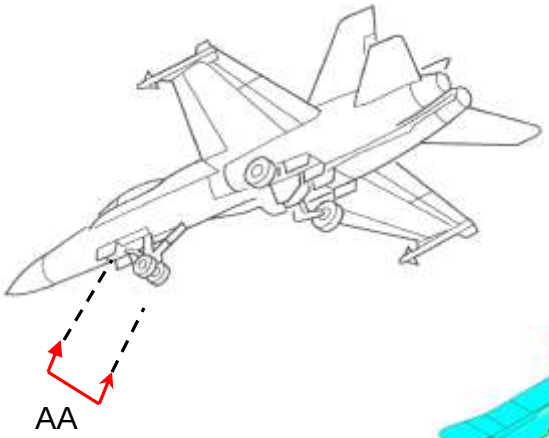


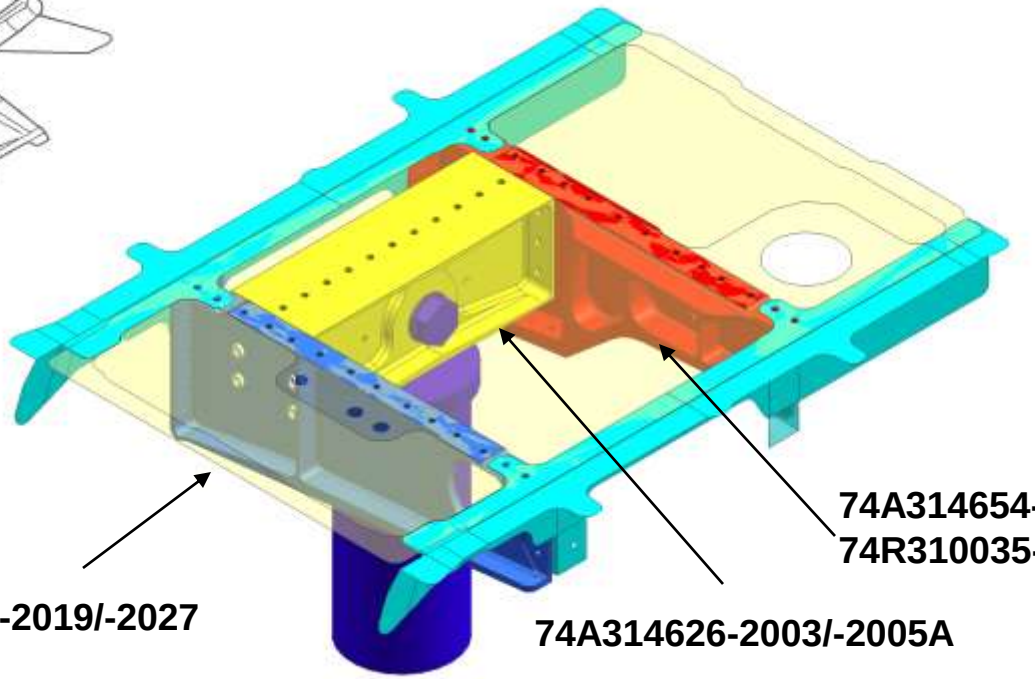
Part Drafted per B/P



Modified the B/P To Reflect the Part

NLG ACTUATOR SUPPORTS





74A314654-2027
74R310035-2005

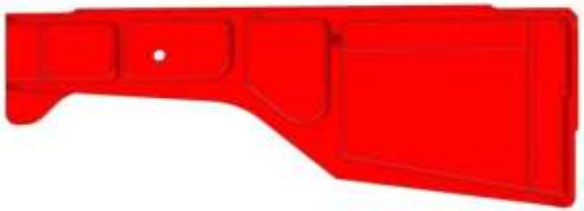
74A314653-2011/-2019/-2027

74A314626-2003/-2005A

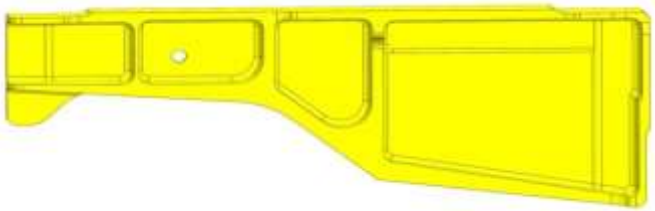
NLG Actuator

FWD

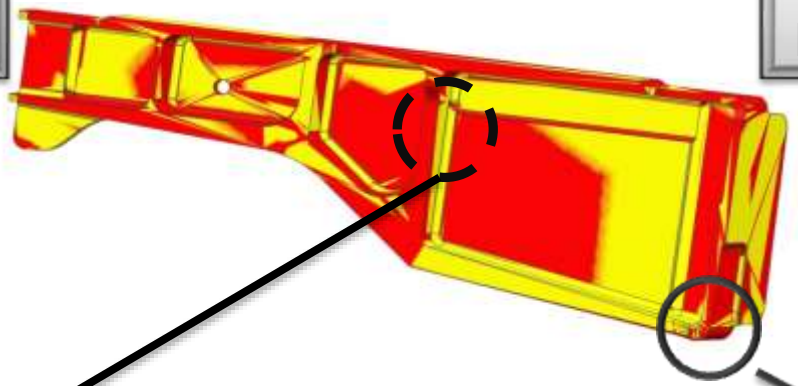
Comparing Manufacturing & Engineering 3D CAD Models



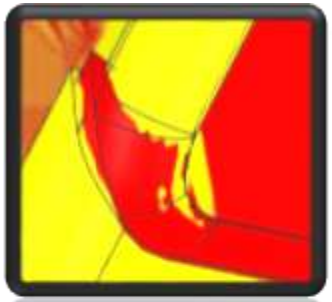
74R310035-2005
Manufacturing Model



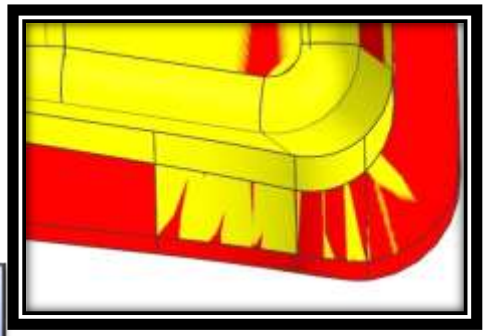
74R310035-2005
Engineering Model



74A310035-2005
Superimposed



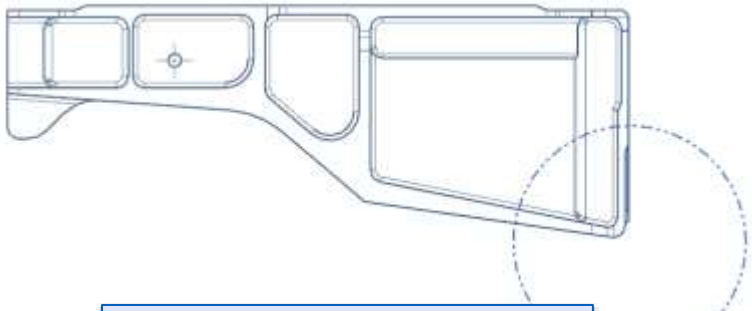
Critical Spot 2:
Smaller Radius



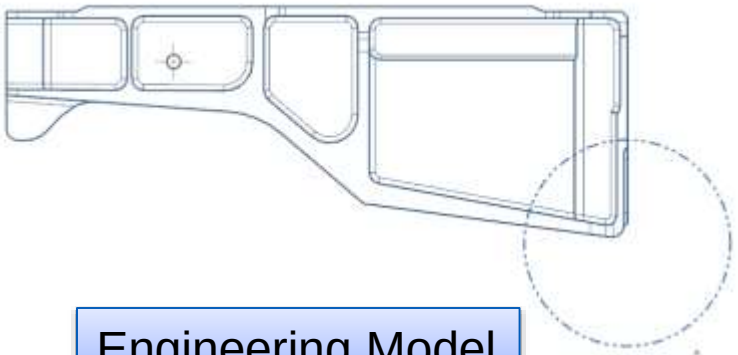
Critical Spot 1:
Smaller Thickness

Δ=0.040”

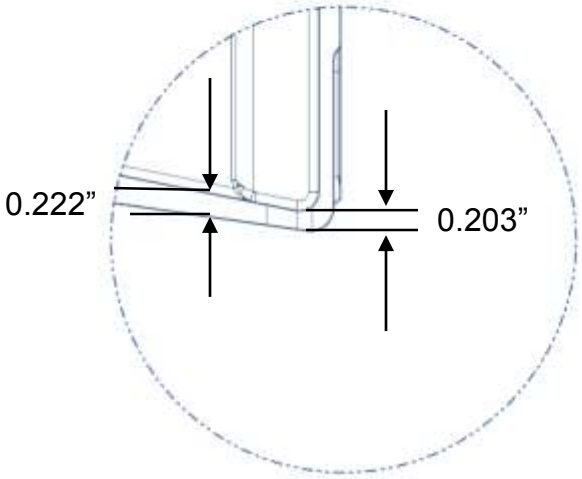
Differences between Manufacturing & Engineering Critical Spot #1 74R310035-2005

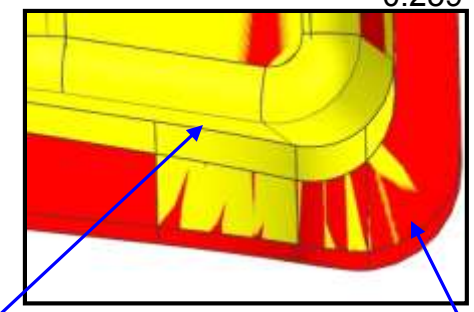


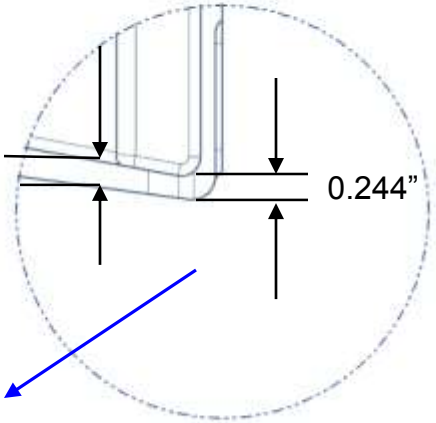
Manufacturing Model



Engineering Model







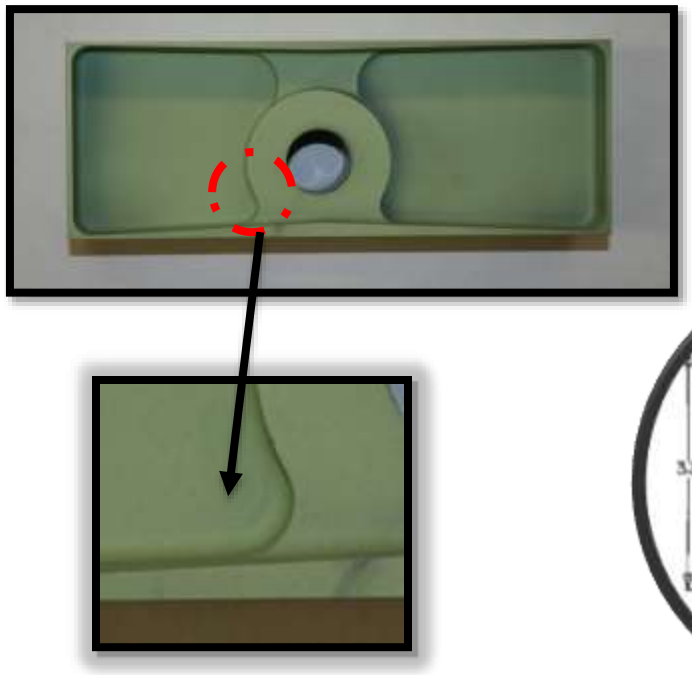
Manufacturing Model

Engineering Model

Manufactured Parts Do Not Conform to B/P

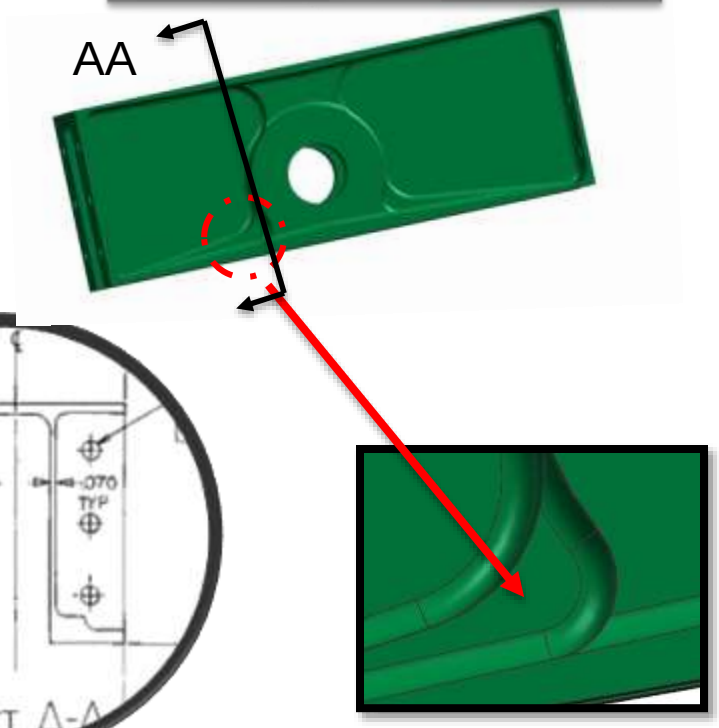
74A314626-2003/74A314626-2005A

Manufactured Part



MISSING STEP ON BOTH SIDES

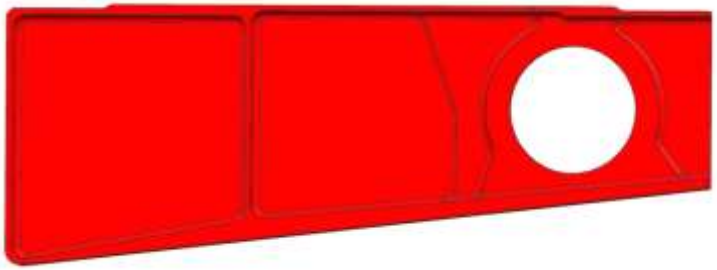
Engineering CAD Model



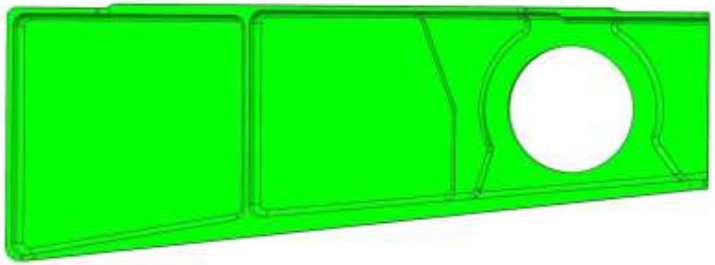
STEP ON BOTH SIDES

Comparing Manufacturing & Engineering 3D Models

74A314653-2011A

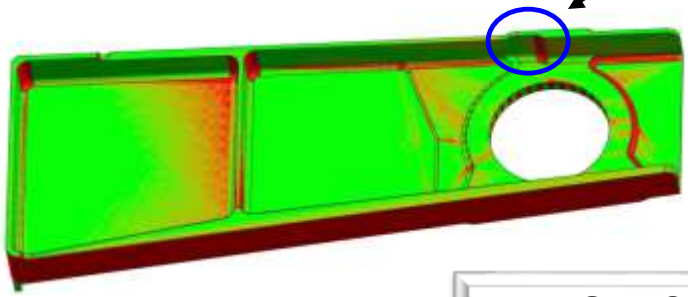


74A314653-2011
Manufacturing Model

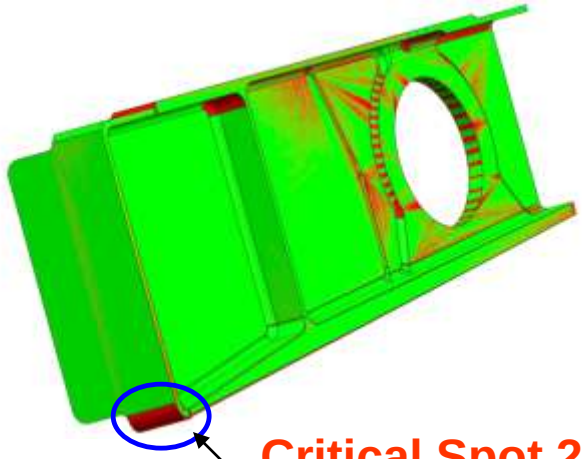


74A314653-2011
Engineering Model

Critical Spot 1



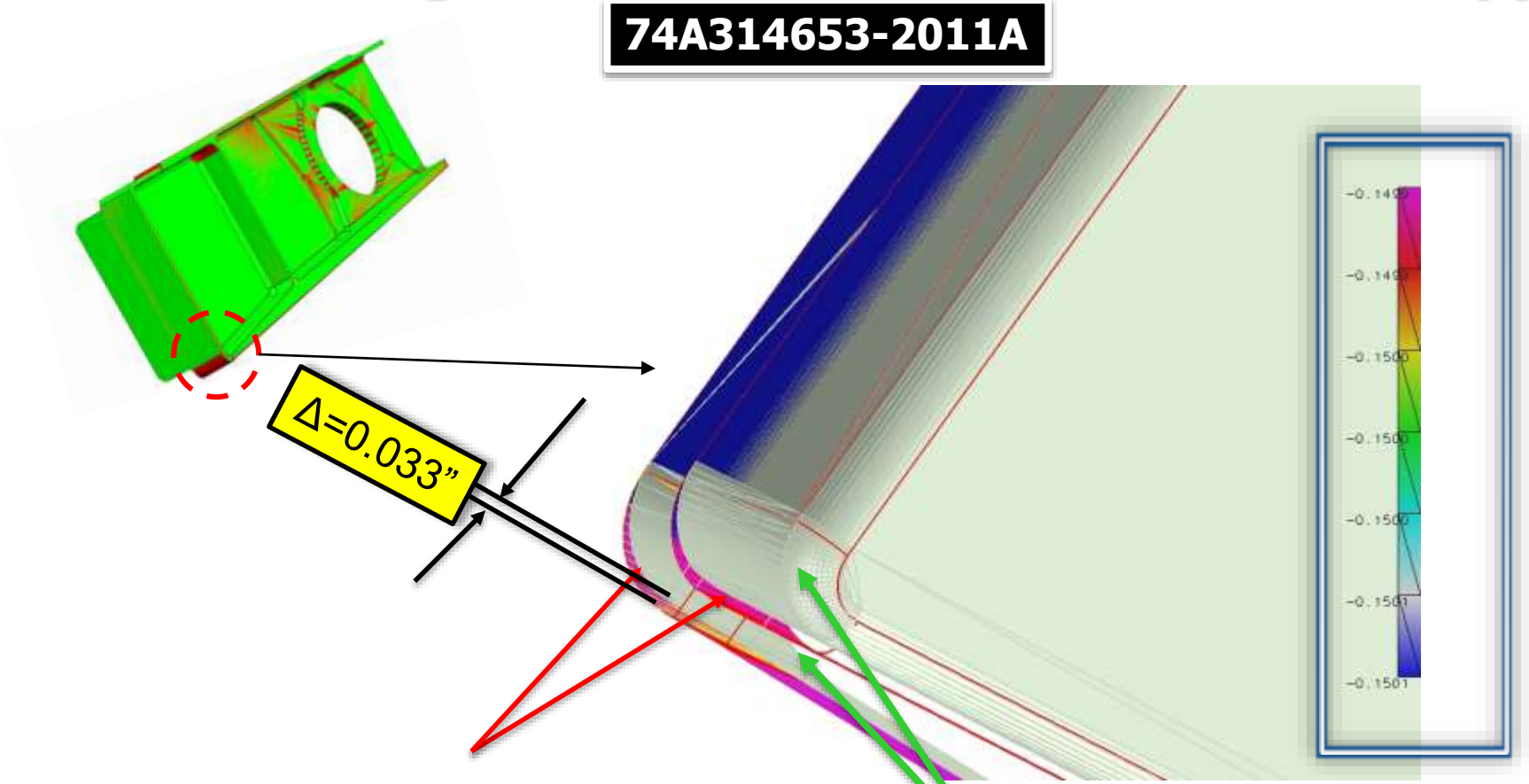
74A314653-2011
Superimposed



Critical Spot 2

Manufacturing & Engineering 3D Models Overlapping

74A314653-2011A



74A314653 Manufacturing Model (Red)

74A314653 Engineering Model (Silver)

Critical Spot 2

Traditional CMM's Approach

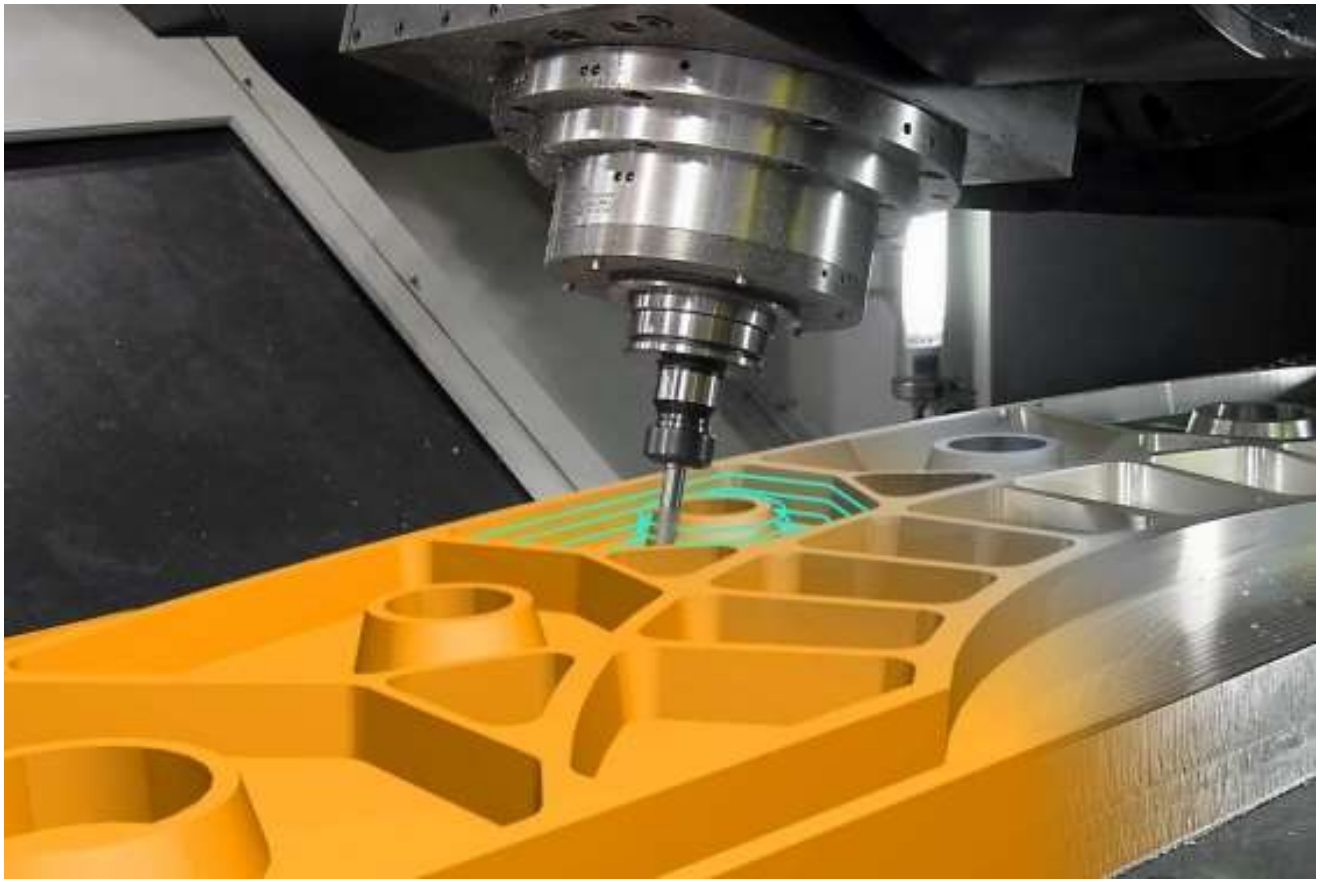
First Article Inspection Report
Form 3: Characteristic Accountability, Verification and Compatibility Evaluation

1. Part Number						2. Part Name			
PRT-MFG-237485						PLATE LOWER			
Characteristic Accountability							Inspection / Test Results		
6. Char No.	6. Reference Location	7. Characteristic Designator	8. Requirement	8a. Unit	8b. Upper Limit	8c. Lower Limit	9. Results	10. Designed Tooling	11. Non Conform Number
1	pg.1, zone 1.A	LINEAR	ANODIZE BLUE PER XYZ-50.				Pass	Visual	
2	pg.1, zone 2.A	LINEAR	.750±.020	in	0.770	0.730	0.74	CMM	
3	pg.1, zone 2.B	LINEAR	.680±.020	in	0.700	0.660	0.661	CMM	
4	pg.1, zone 2.B	LINEAR	.618±.020	in	0.638	0.598	0.62	CMM	
5	pg.1, zone 2.B	ANGULAR	.325±.020	in	0.345	0.305	0.32	Digital Calipers	
6	pg.1, zone 2.C	PROFILE OF A SURFACE	48.56°	deg	49.56	47.56	49.54	Digital Calipers	
7	pg.1, zone 2.C	RADIAL	⌓ .020 A B C	in			0.017	CMM	
8	pg.1, zone 2.D	PERPENDICULARITY	R.125	in	0.130	0.120	0.119	Digital Calipers	
9	pg.1, zone 2.D	LINEAR	⊥ .010 A B	in	0.01	0.01	0.01	Digital Calipers	
10	pg.1, zone 3.C	LINEAR	2.875±.020	in	2.895	2.855	2.89	Digital Calipers	
11	pg.1, zone 3.C	LINEAR	$3.206^{+.003}_{-.004}$	in	3.209	3.202	3.205	Digital Calipers	
12	pg.1, zone 3.C	PERPENDICULARITY	3.503 3.496	in	3.503	3.496	3.5	Digital Calipers	

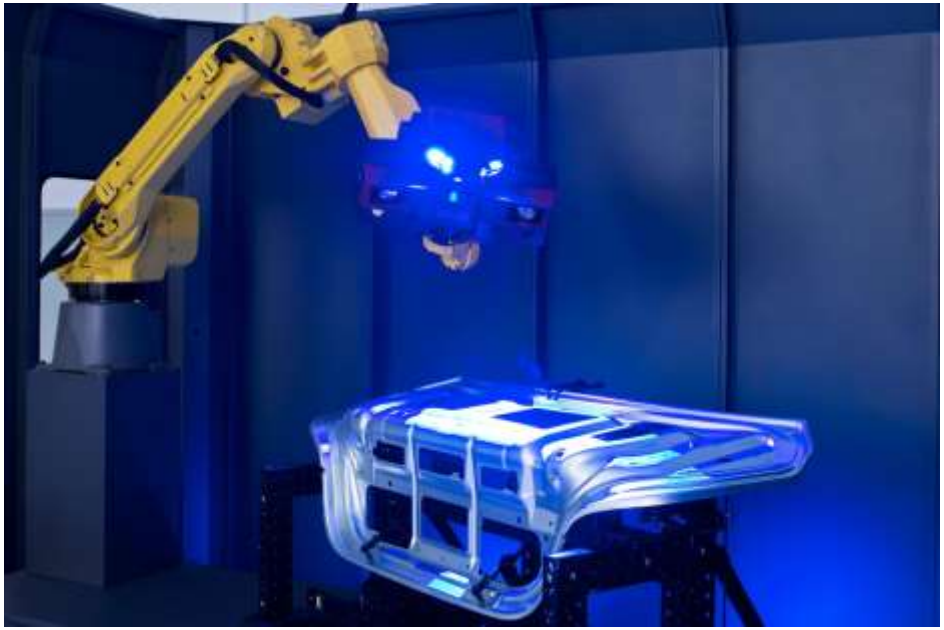
Capital Improvement Project (CIP)

- Approx $36M total investment across three fleet readiness centers
  - FRC-SW - San Diego, CA
  - FRC-SE – Jacksonville, FL
  - FRC-E – New Bern, NC
- In Process Inspection System
  - $800K Y16 / Y17 Project

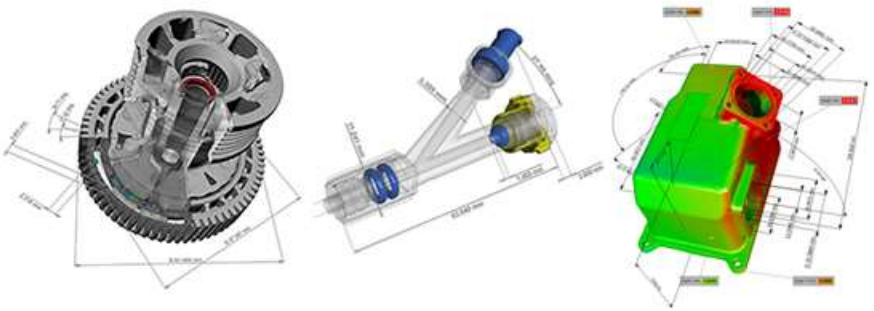
Measuring Large Structure
Manufacturing Parts



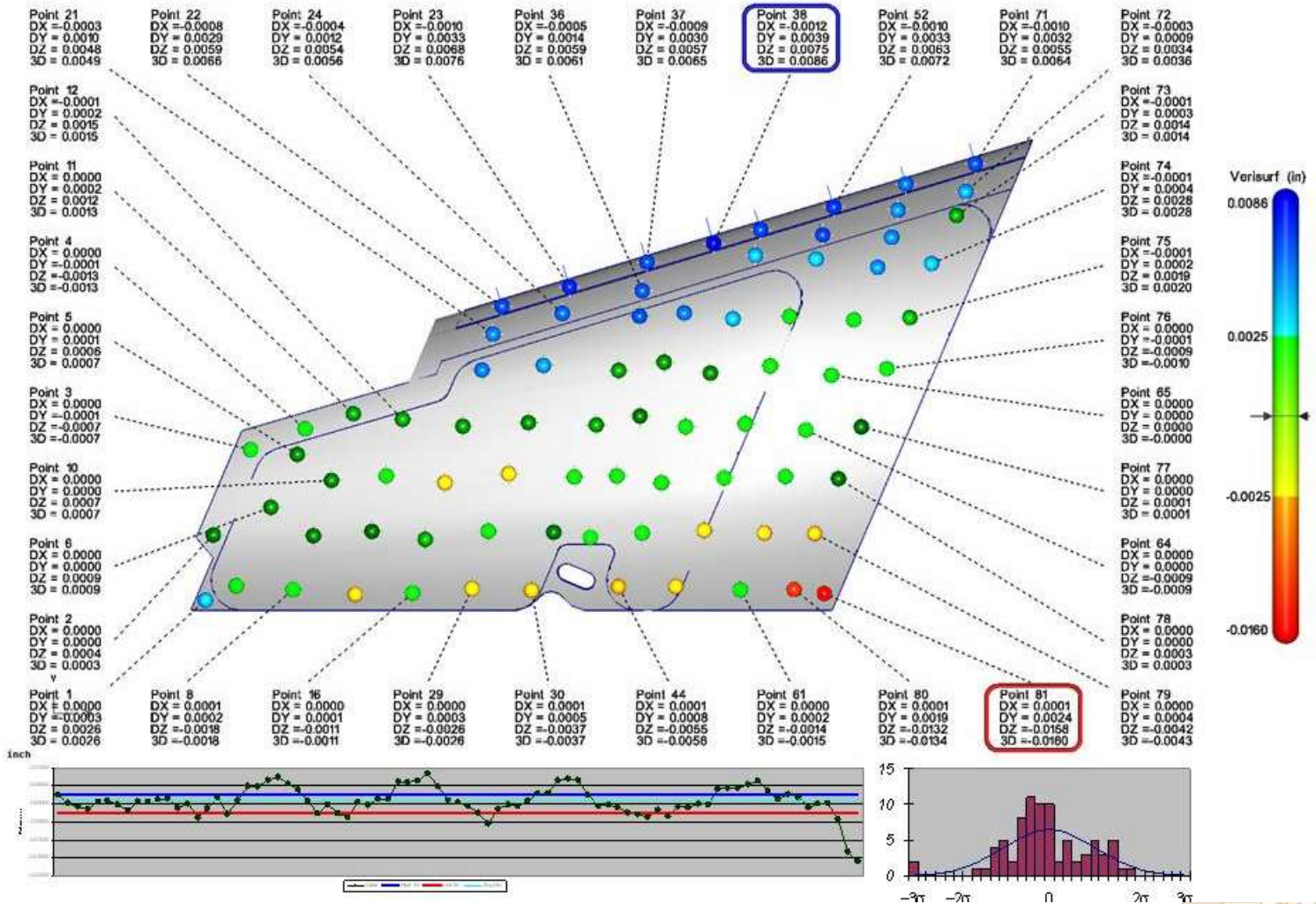
ATOS Scanbox



Cognitens 360 SIMS

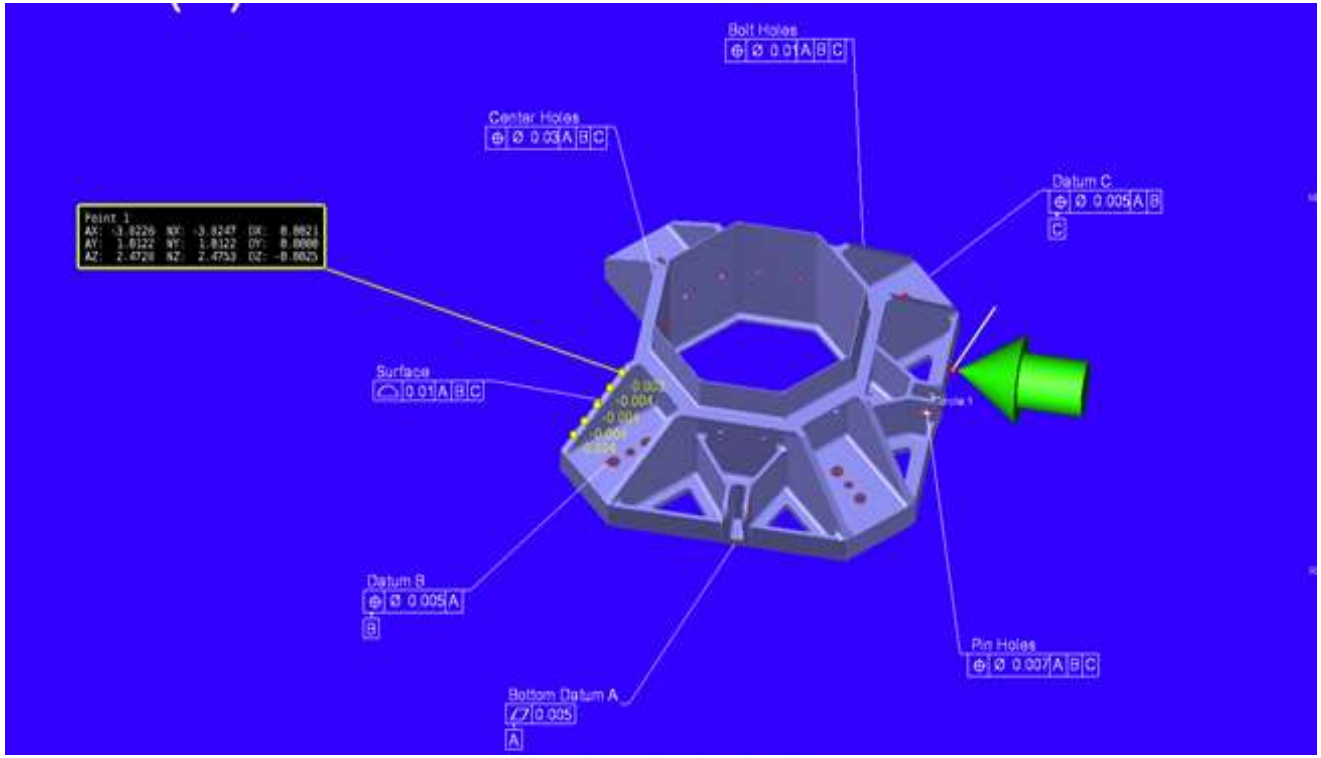


Model-Based Inspection Solutions
QA Reporting to MBD

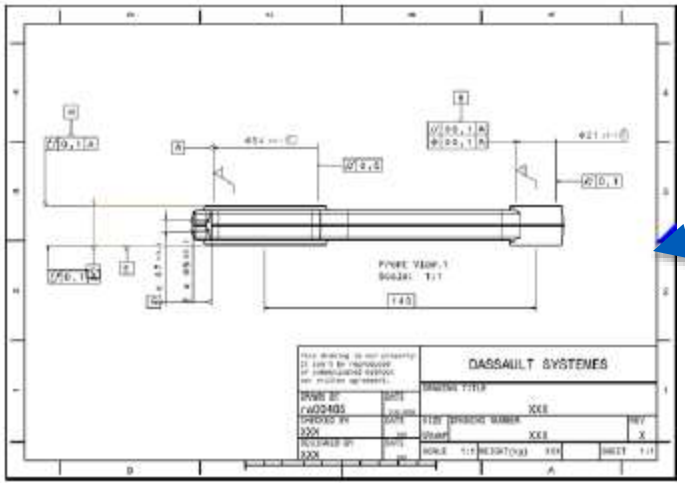


WHAT IS A MBD?

Model Based Definition, MBD is Using the Native CAD Model as the Sole Data Authority

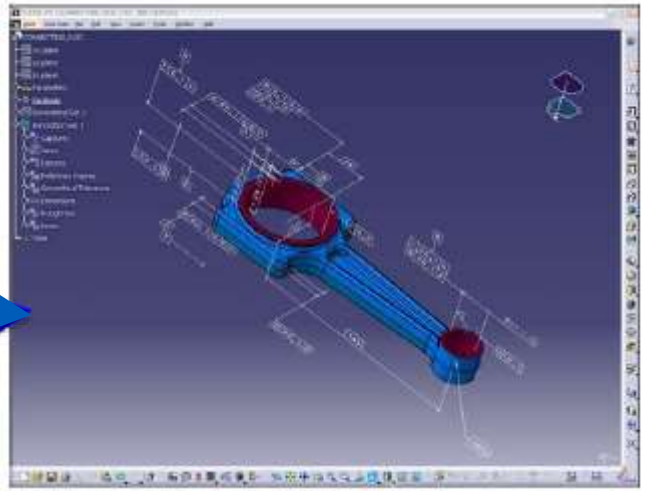


MODEL BASED DEFINITION
MBD

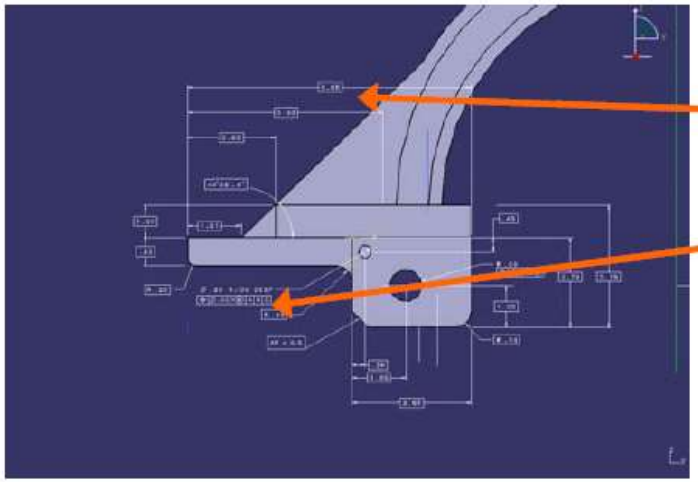


Print:
2D

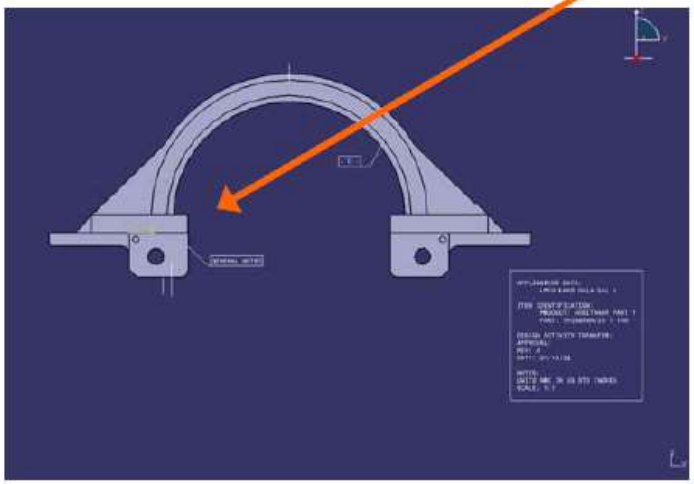
PRESENT &
FUTURE:
3D MBD

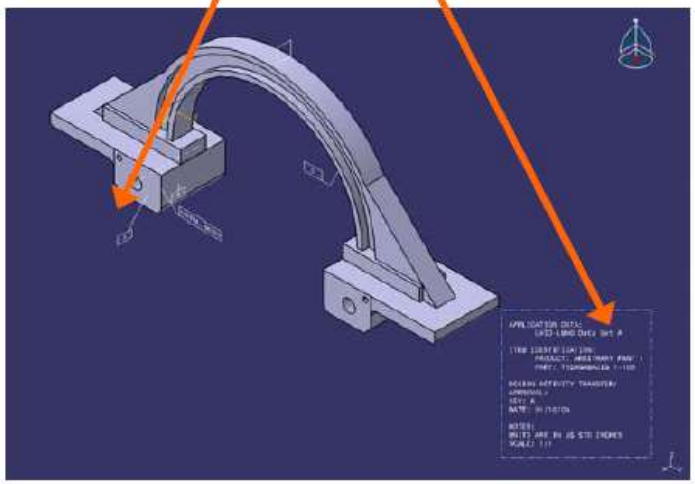


3D SOLID MODEL BASE DEFINITION



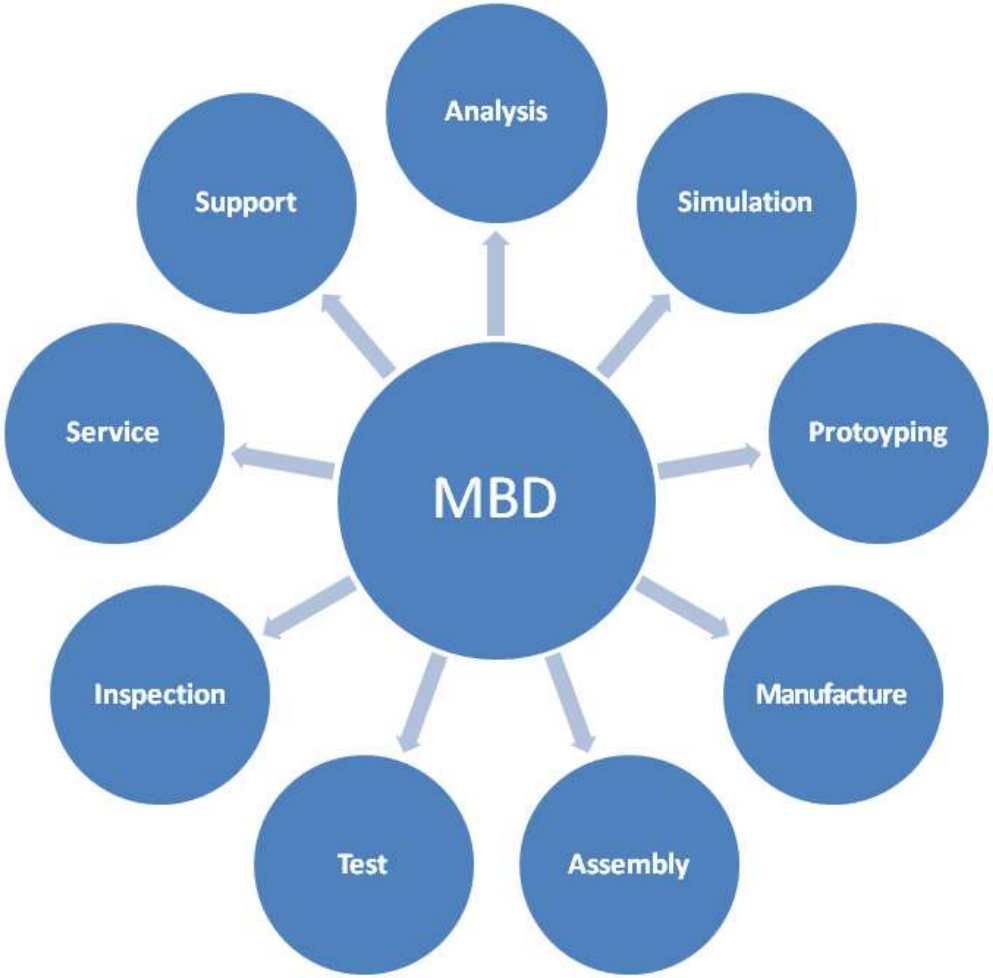
- Dimensions
- Tolerances
- Flag Notes
- Datums
- Annotations





- The Model Based Enterprise (MBE) is made up of many related processes. At its core is the product definition which we refer to as the Model Based Definition (MBD). Another way to define MBD is an annotated 3D CAD Model that contains all the information needed to define a product. This annotated model replaces a traditional drawing. Thus, a drawing is created by exception not as a standard process.

MBD at the center of Product Lifecycle Management



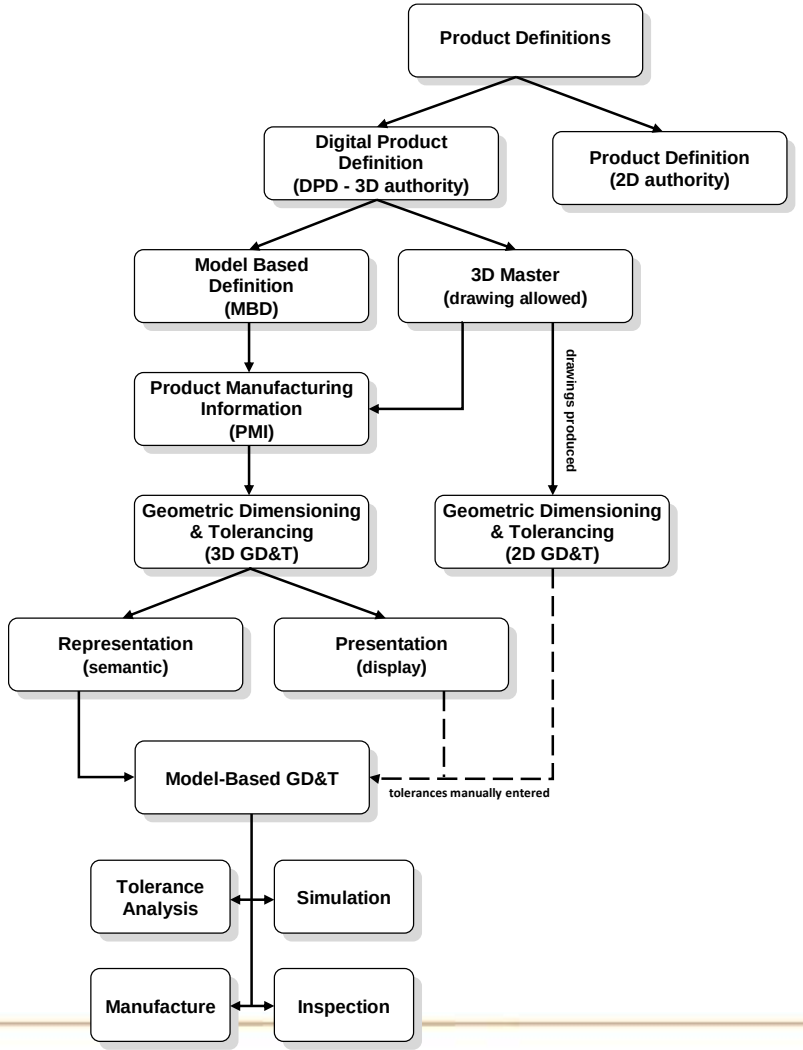
Value of MBD

- With authority bestowed on the model, MBD will:
  - Eliminate errors that result from referencing an incorrect source.
  - Make processes more efficient—no more searching to determine correct revision levels.
  - Eliminate outdated drawings floating around the manufacturing floor.
  - Eliminate discrepancy between the CAD model and 2D documentation.

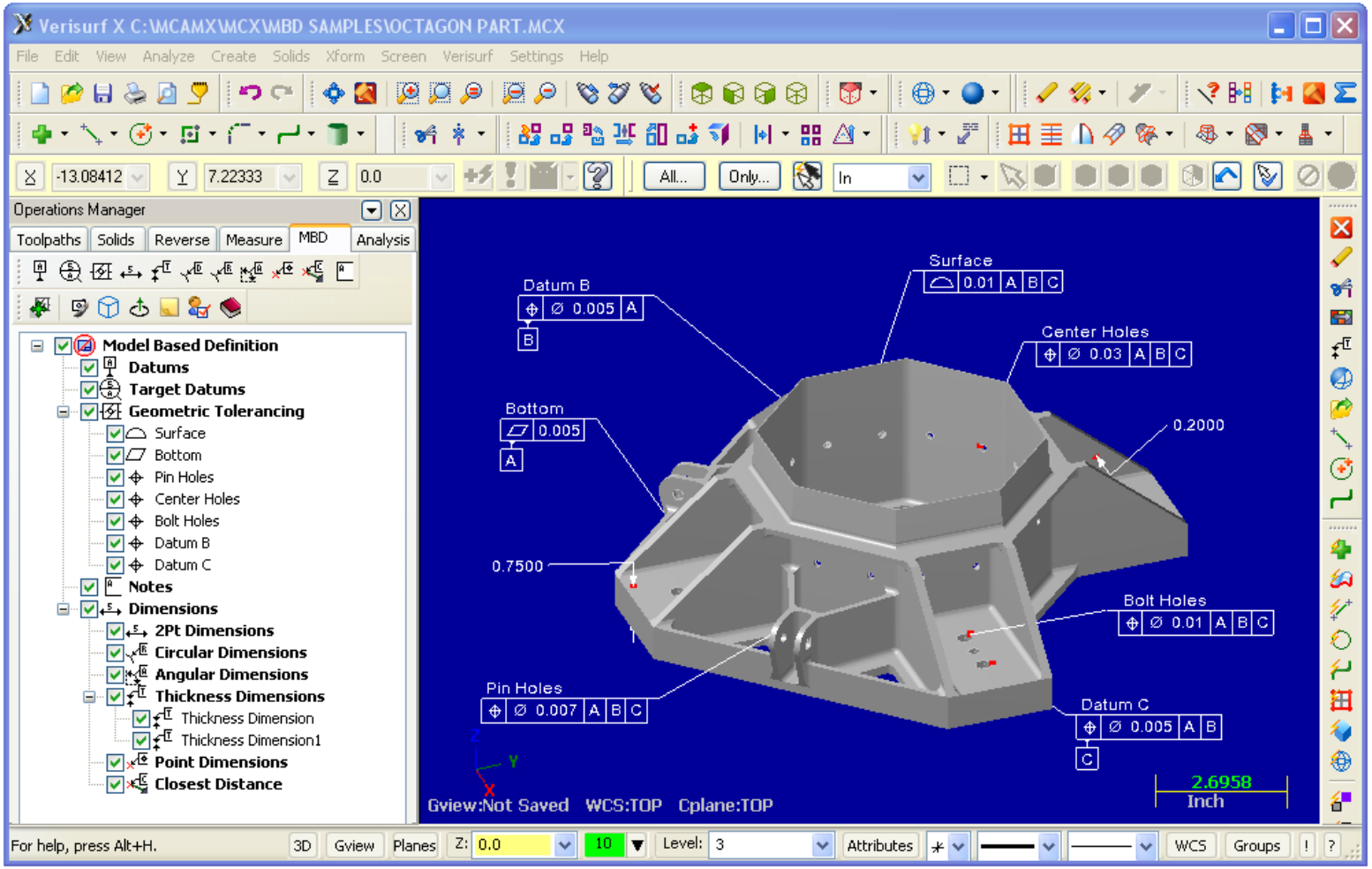
Where MBD Is Best Applied

- Complex surface profiles
- Complex products with large bills of materials
- Mission critical components with high liability
- Long product lives
- Global supply chains
- Stringent regulatory requirements

Product Structure in a MBD Environment



Model-Based GD&T Annotations



Model-Based Enterprise Broken

Model Based Definition
- 3D Solid Models
- CAD Intelligence Utilized
- Automated Digital Processes

Model Based Definition Broken
- Productivity Barrier
- Quality Data Loop Broken
- Statistical Improvement Impeded

Drawing Based Definition
- 2D Drawings
- CAD Intelligence Lost
- Manual Analog Hand Tools

Design
3D Modeling

Engineering
3D Simulation

Manufacturing
3D Tool Paths

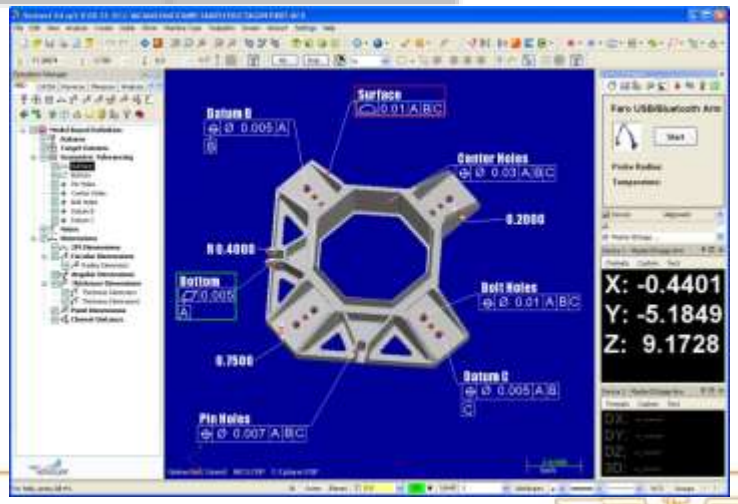
Inspection
2D Drawings

Model-Based Enterprise Applied

Model Based Definition
- 3D Solid Models
- CAD Intelligence Utilized
- Automated Digital Processes

Model Based Definition Extended
- Productivity Improved
- No 2D Drawing Waste
- 3D Quality Data Loop Closed

Model Based Inspection
- 3D Profile with Tolerances
- CAD Intelligence Utilized
- Automated Digital Process



Benefits of Model-Based Measurement and Inspection

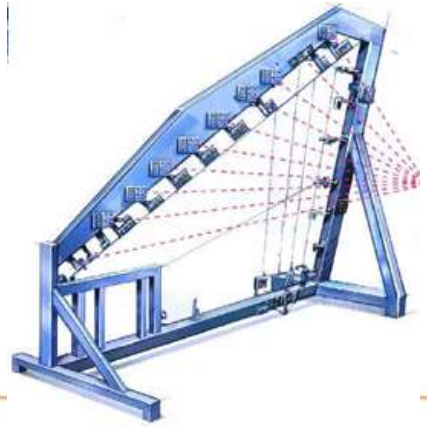
- No 2D Drawings
  - Cost and time eliminated
  - Contradictions removed
- Automated inspection planning
- Automated report formatting
- Accuracy
  - All features included in plan
  - No interpretation errors
  - GD&T rule checking
  - No data entry errors
- Prompted inspection procedures
- Live, graphical measurement display
- Automated reporting
  - No data entry
  - No manual calculations
- Only basic skills needed
- Eliminate CMM overhead (PCMM)
  - No fixtures
  - No part set-up
  - No programming
  - No manual data recording

Model-Based Large Volume Measurement Applications

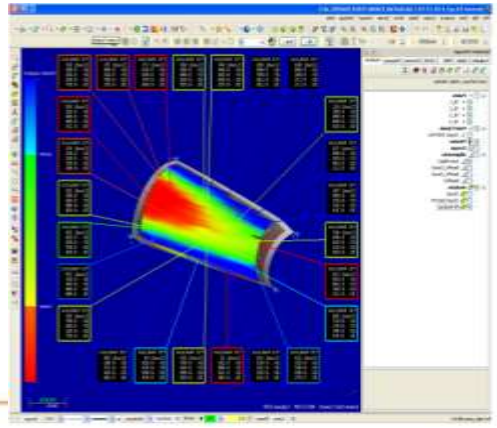
Tooling Fabrication and Validation

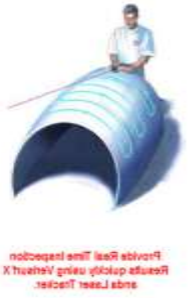
Large volume Inspection

Automated high precision inspection and R&R studies



Real time Model-Based Inspections





Model-Based Inspection Solutions
Import 3D CAD & MBD

- CATIA – Dassault
- UG - Siemens
- Pro/ENGINEER - PTC
- SolidWorks - Dassault
- Inventor - Autodesk
- SolidEdge - Siemens

Autodesk

SolidWorks

NX UNIGRAPHICS

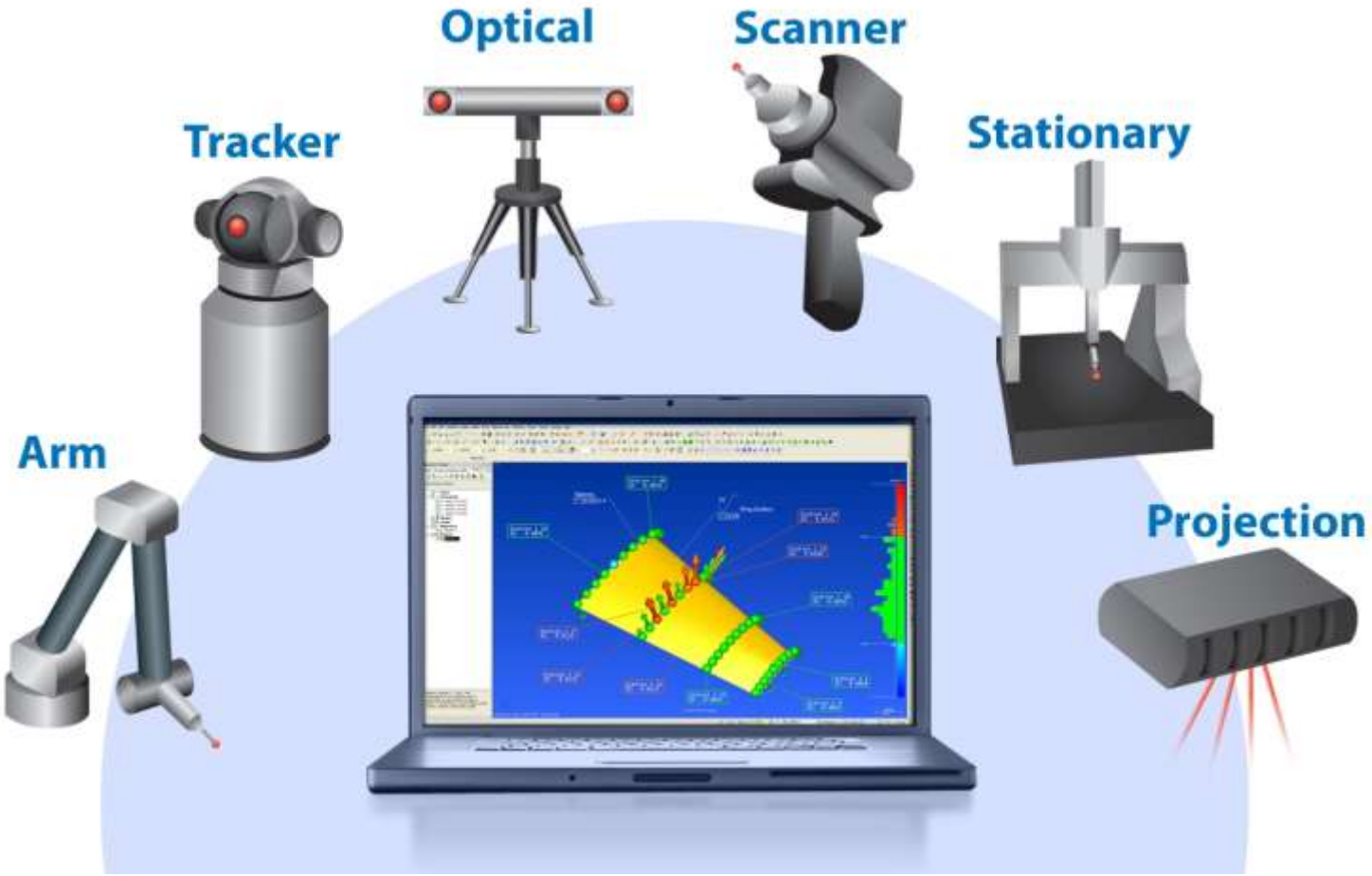
DASSAULT SYSTEMES

SOLID EDGE

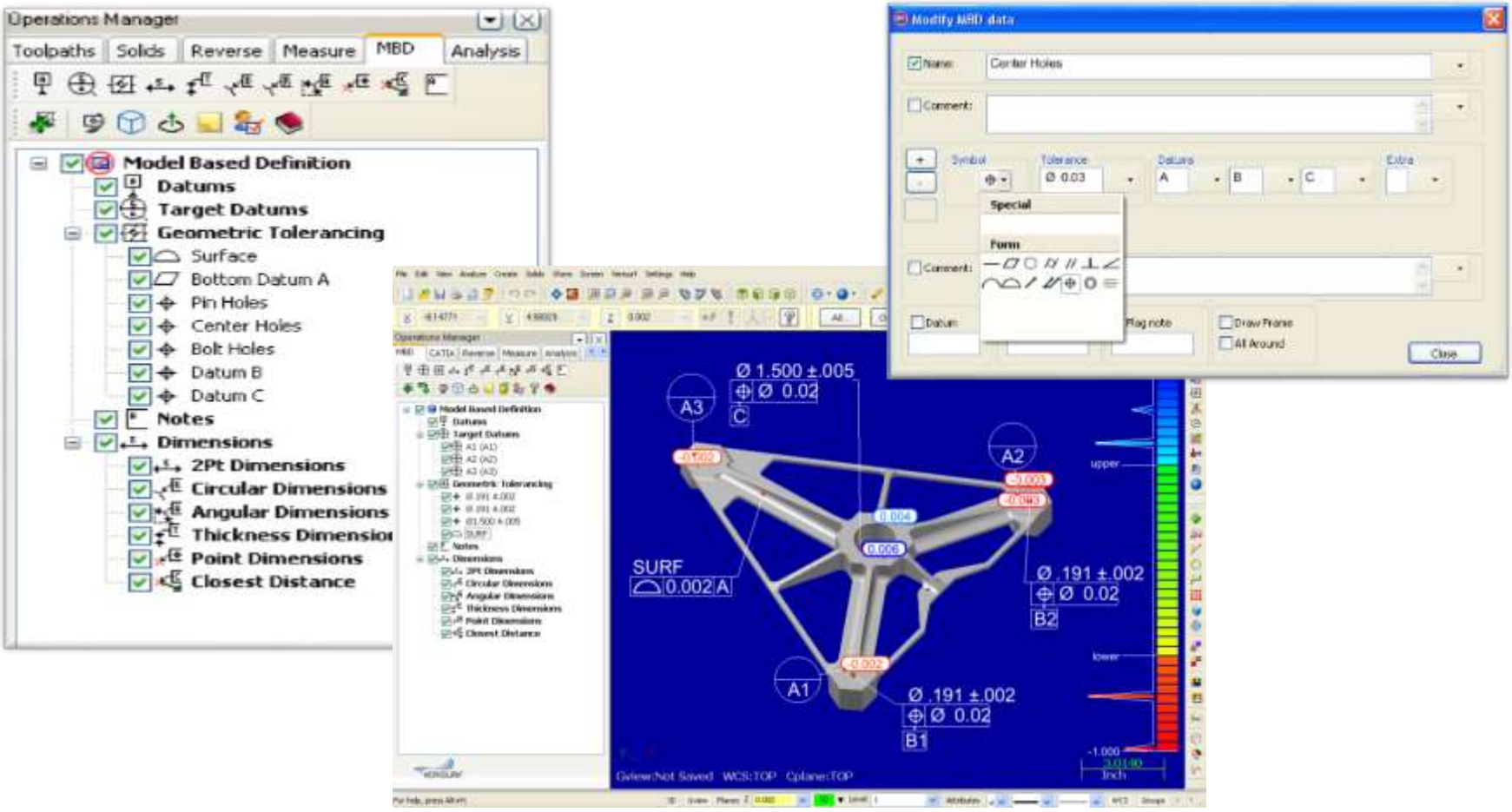
PTC

Mastercam V8 Files (*.MC8)
All Mastercam Files (*.MCX;*.EMCX;*.MC9;*.MC8)
IGES Files (*.IGS;*.IGES)
AutoCAD Files (*.DWG;*.DXF;*.DWF)
Parasolid Files (*.X_T;*.X_B;*.XMT_TXT)
Pro/E Files (*.PRT;*.ASM;*.PRT.*;*.ASM.*)
ACIS Kernel SAT Files (*.SAT;*.SAB)
STEP Files (*.STP;*.STEP)
VDA Files (*.VDA)
Rhino 3D Files (*.3DM)
SolidWorks Files (*.SLDPRT;*.SLDASM)
SolidWorks Drawing Files (*.SLDDRW)
Solid Edge Files (*.PAR;*.PSM;*.ASM)
Autodesk Inventor Files (*.IPT;*.IAM)
Autodesk Inventor Drawing Files (*.IDW)
KeyCreator Files (*.CKD)
ASCII Files (*.TXT;*.CSV;*.DOC)
StereoLithography Files (*.STL)
Catia V4 Files (*.MODEL;*.EXP)
Catia V5 Files (*.CATPART;*.CATProduct)
SpaceClaim Files (*.SCDOC)
Alibre Design Files (*.AD_PRT;*.AD_SMP)
HPGL Plotter files (*.PLT)
Cadkey CDL Files (*.CDL)
PostScript Files (*.EPS;*.AI;*.PS)
Catia V4 Files (Moldplus) (*.model; *.exp)
Catia V5 Files (Moldplus) (*.CATPart; *.CATProduct)
Verisurf STL files (*.STL)
Unigraphics NX (*.PRT)
All Files (*.*)

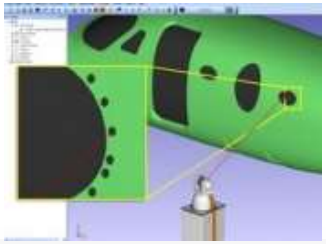
Model-Based Inspection Solutions Connect To Metrology Devices

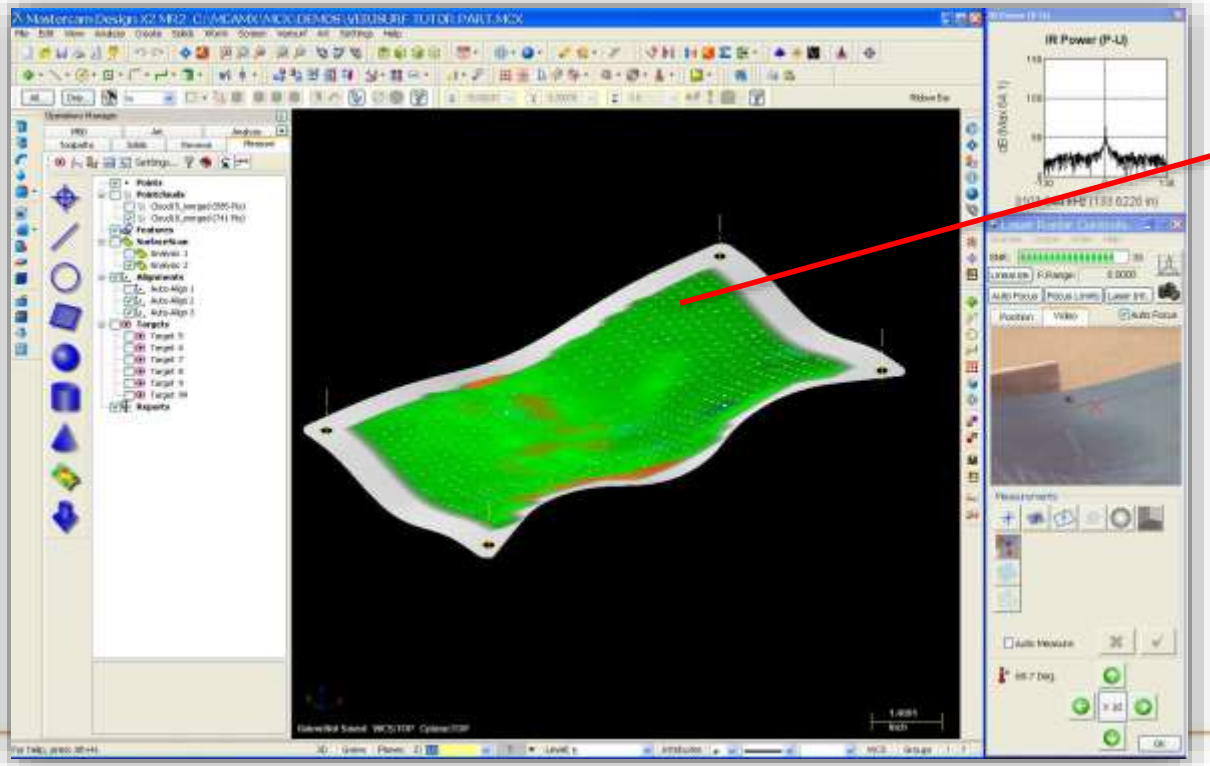


Model-Based Inspection Solutions
Create MBD

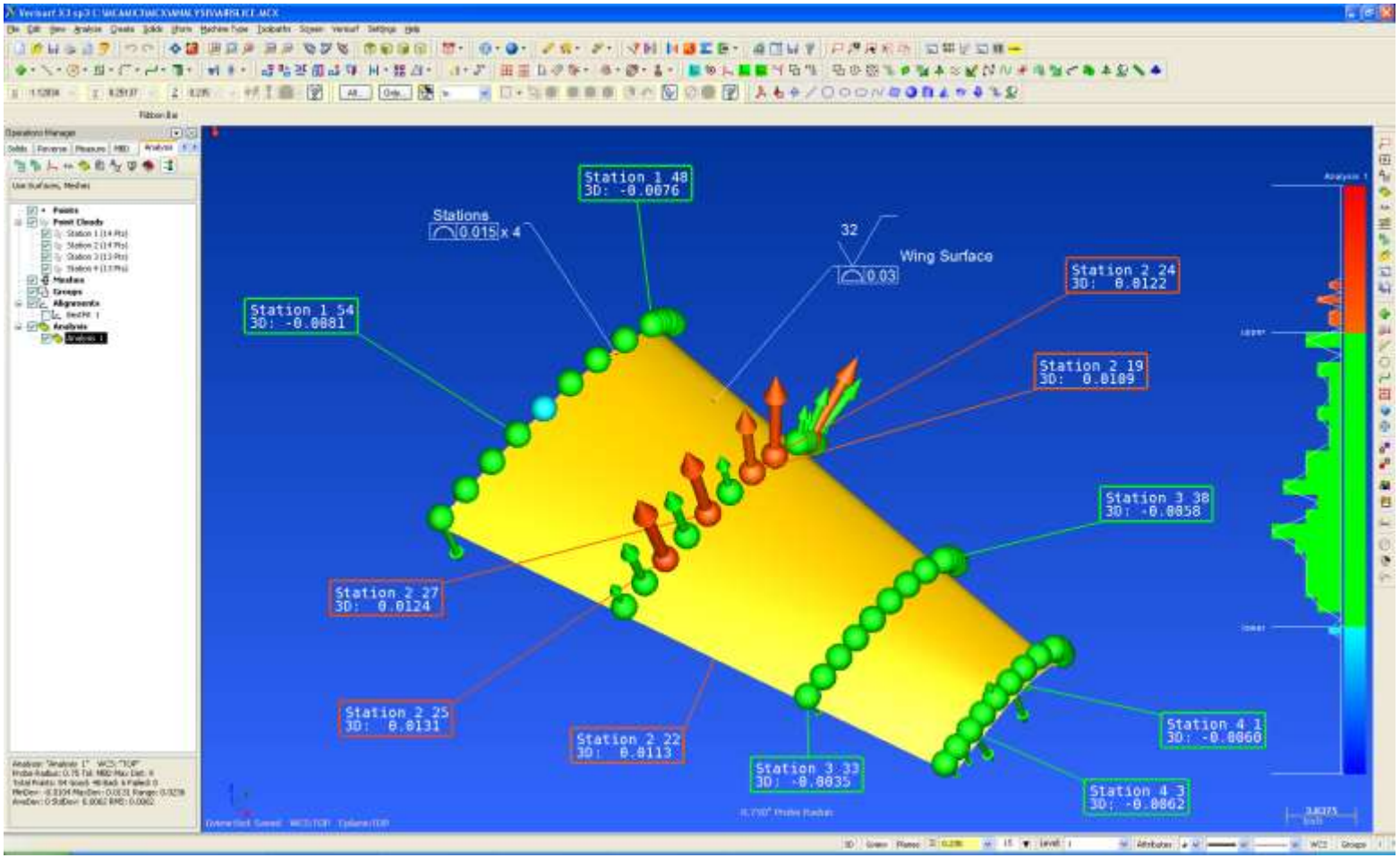


Model-Based Inspection Solutions
Automated Inspection Plans to MBD





Model-Based Inspection Solutions
Analyze & Display Inspection Data



MBD Implementation Levels

Level 0	• Drawing Centric • Disconnected Manufacturing - Disconnected Enterprise • Primary Deliverable: 2D Drawing
Level 1	• Model Centric • Neutral Model CAM - Disconnected Enterprise • Primary Deliverable: 2D Drawing and Neutral CAD Model
Level 2	• Model Centric • Native Model CAM - Disconnected Enterprise • Primary Deliverable: 2D drawing and Native CAD Model
Level 3	• Model Based Definition • Native Model CAM - Disconnected Enterprise • Primary Deliverable: 3D Annotated Model and LightWeight viewable
Level 4	• Model Based Definition • Integrated Manufacturing - Disconnected Enterprise • Primary Deliverable: 3D Annotated Model and LightWeight viewable via PLM
Level 5	• Model Based Enterprise • Integrated Manufacturing - Integrated Internal Enterprise • Primary Deliverable: Digital Product Definition Package and TDP
Level 6	• Model Based Enterprise • Integrated Manufacturing - Integrated Extended Enterprise • Primary Deliverable: Digital Product Definition Package and TDP via the web

Courtesy of Model Based Enterprise

Challenges
Interoperability

- CATIA – Dassault
- UG - Siemens
- Pro/ENGINEER - PTC
- SolidWorks - Dassault
- Inventor - Autodesk
- SolidEdge - Siemens

Autodesk

SolidWorks

NX UNIGRAPHICS

DASSAULT SYSTEMES

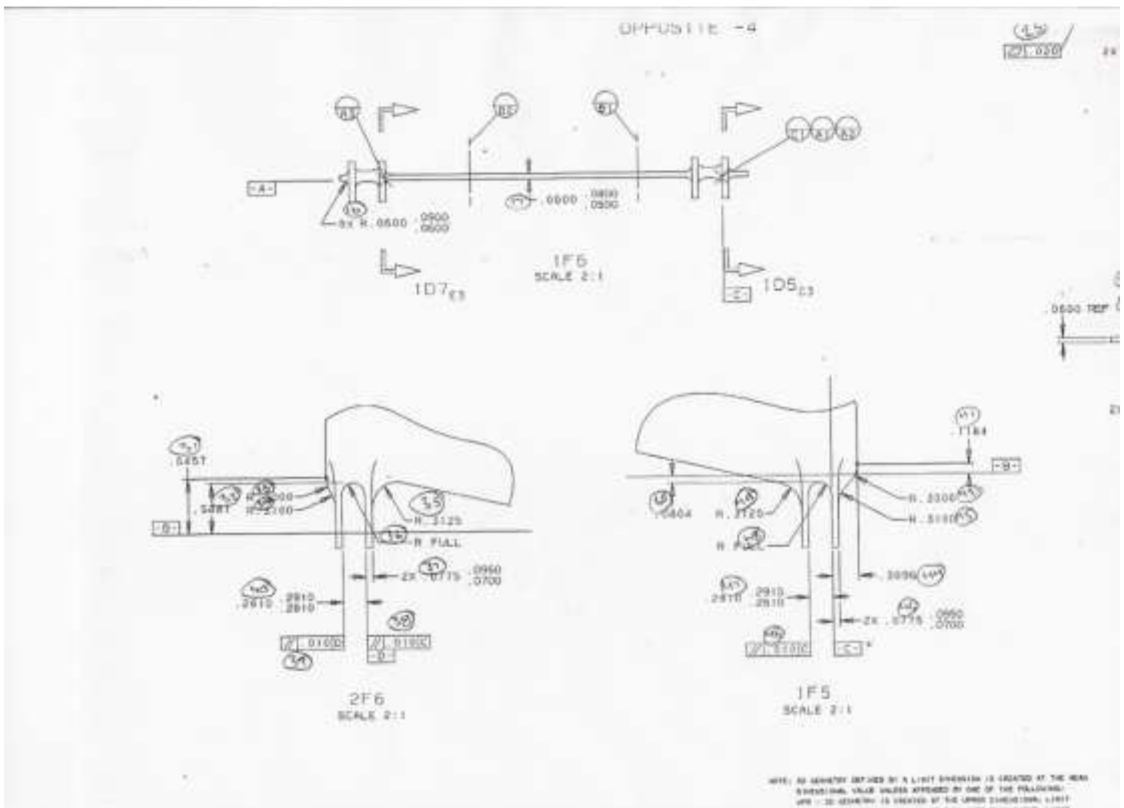
SOLID EDGE

PTC

Mastercam V8 Files (*.MC8)
All Mastercam Files (*.MCX;*.EMCX;*.MC9;*.MC8)
IGES Files (*.IGS;*.IGES)
AutoCAD Files (*.DWG;*.DXF;*.DWF)
Parasolid Files (*.X_T;*.X_B;*.XMT_TXT)
Pro/E Files (*.PRT;*.ASM;*.PRT.*;*.ASM.*)
ACIS Kernel SAT Files (*.SAT;*.SAB)
STEP Files (*.STP;*.STEP)
VDA Files (*.VDA)
Rhino 3D Files (*.3DM)
SolidWorks Files (*.SLDPRT;*.SLDASM)
SolidWorks Drawing Files (*.SLDDRW)
Solid Edge Files (*.PAR;*.PSM;*.ASM)
Autodesk Inventor Files (*.IPT;*.IAM)
Autodesk Inventor Drawing Files (*.IDW)
KeyCreator Files (*.CKD)
ASCII Files (*.TXT;*.CSV;*.DOC)
StereoLithography Files (*.STL)
Catia V4 Files (*.MODEL;*.EXP)
Catia V5 Files (*.CATPART;*.CATProduct)
SpaceClaim Files (*.SCDOC)
Alibre Design Files (*.AD_PRT;*.AD_SMP)
HPGL Plotter files (*.PLT)
Cadkey CDL Files (*.CDL)
PostScript Files (*.EPS;*.AI;*.PS)
Catia V4 Files (Moldplus) (*.model; *.exp)
Catia V5 Files (Moldplus) (*.CATPart; *.CATProduct)
Verisurf STL files (*.STL)
Unigraphics NX (*.PRT)
All Files (*.*)

Challenges

Eliminating Drawings



TRI-TECH

B/P TOLERANCE

CUSTOMER: ELECTROL MFG. CO

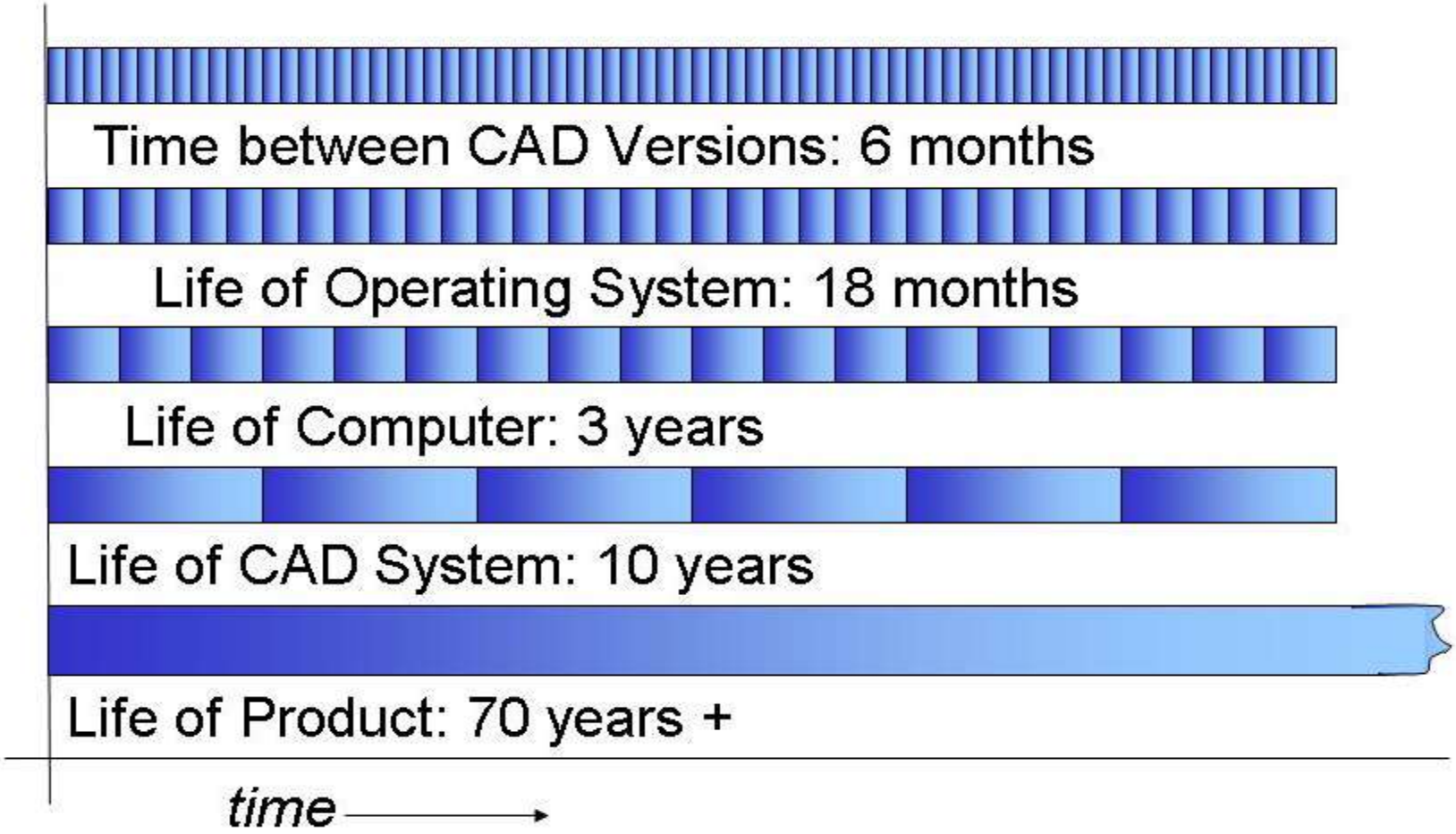
PART NO.	Rev.	PART NAME
181A8038-4	A	LINK FITTING

Qty. Ordered	Qty. Insp.	Qty. Accepted	Qty. Rejected	Rejection No.	Inspector
75	85	75	0		

ITEM #	B/P LOC.	DWG. DIMENTION	ACTUAL DIMENTION	ACCEPTED YES	ACCEPTED NO	GAGE USED	REMARKS
1	G-6	2X R .3125	[illegible]	✓			
2	H-6	4.8800	[illegible]	✓			
3	G-6	4.0000 BSC	SET	✓			
4	G-6	2X R .3125	[illegible]	✓			
5	G-6	[illegible] BSC	SET	✓			
6	G-6	[illegible] BSC	SET	✓			
7	G-6	1.1031	[illegible]	✓			
8	G-6	.7500 BSC	SET	✓			
9	F-6	4.0780	[illegible]	✓			
10	F-6	3.0000 BSC	SET	✓			
11	F-6	1.0900 BSC	SET	✓			
12	G-6	1.1200	[illegible]	✓			
13	G-6	.4425 BSC	SET	✓			
14	G-6	1.5000 BSC	SET	✓			
15	G-7	2.0307	[illegible]	✓			
16	E-7	8X R .0800/.0500	[illegible]	✓			
17	E-7	.0500/.0800	[illegible]	✓			
18	F-4	[illegible] .005	[illegible]	✓			
19	F-3	.8447	[illegible]	✓			
20	F-3	.8471	[illegible]	✓			
21	F-3	.1819	[illegible]	✓			
22	E-3	.2890	[illegible]	✓			
23	E-3	R .2300/.2800	[illegible]	✓			
24	E-4	2X R .2020	[illegible]	✓			
25	E-4	[illegible] .020	[illegible]	✓			

Challenges

Legacy Data



Challenges
CAD Translation & Validation

When Boeing DPD data containing 3D geometry is received in translated format (e.g., IGES, STEP), the supplier must verify their translation of each dataset or have a process to verify and validate translation software (per Section 3.), in order to maintain authority status.

Boeing Standard D6-51991

QUALITY ASSURANCE STANDARD FOR DIGITAL PRODUCT DEFINITION AT BOEING SUPPLIERS, D6-51991, REV J, September 17, 2010

9.2 Translations - Suppliers are responsible for all dataset translations used for manufacturing and inspection, and must have a clear documented process for each. The documented process must include a method to verify the accuracy of translations. (See definitions for description of “translation”.)

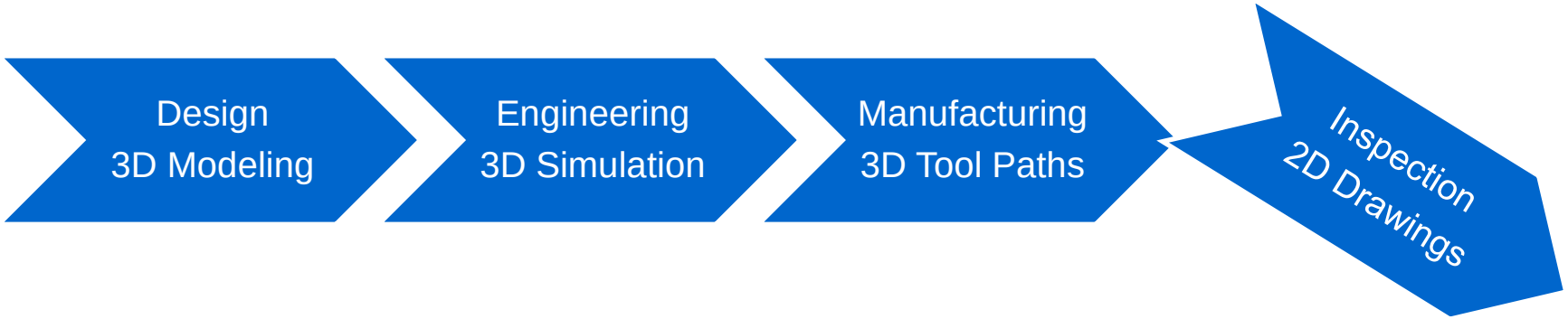
9.2.1. Acceptance criteria for accuracy of translated surface profile/geometry, (tolerance) must be determined by the supplier, and must ensure the end product will be within engineering tolerance/specification. Objective evidence of translation validation must be retained. (Typical allowable deviation tolerance is .0001 to .001 inch)

9.2.2. Suppliers must be able to demonstrate the CAD translation process, including verification/interrogation methods used, and the ability to identify known discrepancies.

9.2.3. The verification process for translation of datasets containing 3D annotation, i.e. feature control frames, dimensions, text, and/or surface geometry must ensure that all intended entities are accounted for in the translated dataset.

Challenges

Changing Process



Challenges
Changing People

Predictions

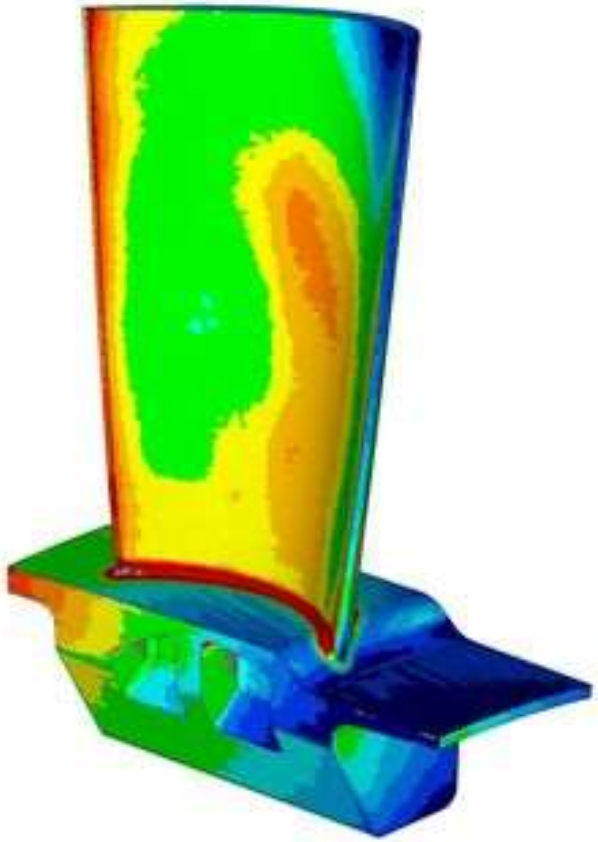
Predictions

- 3D Global Supply Chains
- Elimination of 2D Drawings
- STEP AP242 Will Enhance Interoperability
- Increased Noncontact Inspection & 3D Scanning
- Cloud Based Inspection Databases
- SPC of Key Characteristics
- 3D Maintenance Repair Overhaul

Additional Information

- STEP AP242 - Managed Model Based 3D Engineering
- ISO 10303 - STEP Standard for the Exchange of Product model data
- Quality Information Framework (QIF)
- Aerospace Industries Association (AIA) Engineering Data Interoperability Group (EDIG)
- Automotive Industry Action Group (AIAG)
- Model Based Enterprise

Thank You!



JTEG Joint Technology Exchange Group

Joint Solutions for Depot Maintenance

Reverse Engineering, 3D Scanning & Tolerancing

Review & Wrap-Up

25 August 2015

JTEG Joint Technology Exchange Group

Joint Solutions for Depot Maintenance

Next JTEG Technology Forum

Cold Spray Repair

29 September 2015