Belcan

Manufacturing x Digital

Engineering Better Outcomes

Characteristic Accountability

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Belcan Digital Engineering Solutions

Vision

Belcan Digital Engineering Solutions is your trusted partner to bridge strategy and execution to achieve your digital vision.

Strategy

- Purpose and Scope
- Readiness Assessment
- Digital Capability Targets
- Strategy and Governance
- Viable Business Case
- Executive Support
- Enterprise Lead Team
- Transformation Roadmap
- Org Change Management

Execution

- Agile Task Execution
- Industry Standard Alignment
- Creator and Consumer Training
- Software Selection
- Pilot Execution
- Digital Thread Traceability
- Supply Chain Enablement
- Process Automation
- Rapid Response

Lead Team

- **Experience:** 10 SMEs, each with 5+ Years of MBE Implementation
- **Industry Engagement:** ASME, DMSC, DEDMWG, AIA, INCOSE, CCSU
- **Certifications:** Agile, ASME GD&T Senior Level, OCSMP
- **Software:** Tool Agnostic, Multi-CAD/PLM/MBE/MBSE

Belcan Overview

- 65 years of Engineering Better Outcomes
- Global Delivery Network
- 10,000 Professionals
- Annual Revenue of ~$1B

Aerospace · Defense · Automotive · Government

Space · Marine · Off-Highway · Industrial

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Terminology

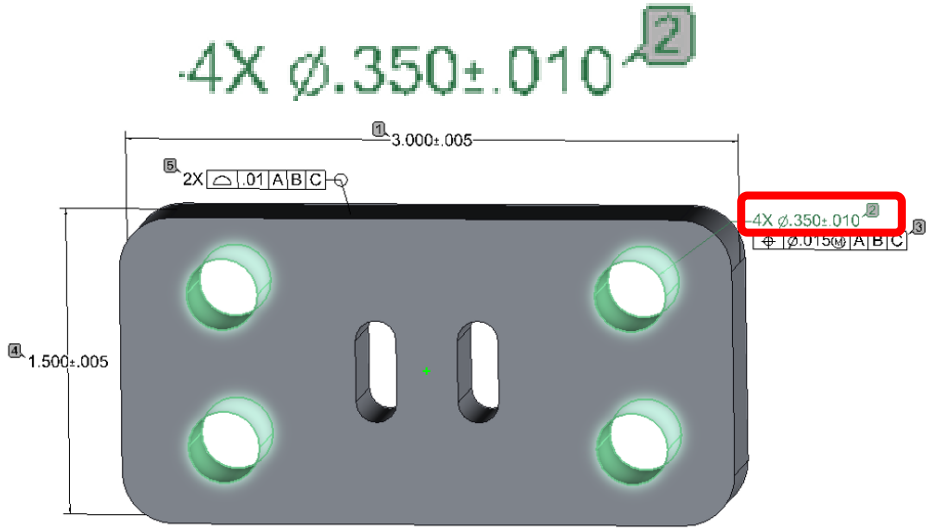
Characteristic: a verification requirement such as a tolerance or specification that is conveyed through the engineering definition

Characteristic Tag: a human and/or machine-readable tag applied to a characteristic

Bill of Characteristics (BoC): a list of all the characteristics applied to a product

Characteristic Accountability: ensuring all characteristic requirements have been met with traceability through verification results

Characteristic **Characteristic Tag**



Bill of Characteristics (BoC)

Bill of Characteristics [042a54c3-3330-4d25-ab51-0f6956b8517c]

Information | Bill of Characteristics [042a54c3-3330-4d25-ab51-0f6956b8517c]

ISIR | Report Type | Reset | Decolorize | Hide | Re-Balloon | Export | Import | Bind | HTML Report | 3D HTML Report | PDF Report | Publish | Import

Tag	Saved View	Feature Name	Annotation Name	GD&T	(-)	/	(+)	DRF
1	01_TOP	Opposite Planes 517	ad21	3.000 ±.005	-.005	3.000	.005	-
2.1	01_TOP	Cylinder 512	ad11	Ø.350 ±.010	-.010	.350	.010	-
2.2	01_TOP	Cylinder 514	ad11	Ø.350 ±.010	-.010	.350	.010	-
2.3	01_TOP	Cylinder 513	ad11	Ø.350 ±.010	-.010	.350	.010	-
2.4	01_TOP	Cylinder 515	ad11	Ø.350 ±.010	-.010	.350	.010	-
3.1	01_TOP	Cylinder 512	gp0	⌖ Ø.015Ⓜ A B C	-	-	.015	A/B/C
3.2	01_TOP	Cylinder 514	gp0	⌖ Ø.015Ⓜ A B C	-	-	.015	A/B/C
3.3	01_TOP	Cylinder 513	gp0	⌖ Ø.015Ⓜ A B C	-	-	.015	A/B/C
3.4	01_TOP	Cylinder 515	gp0	⌖ Ø.015Ⓜ A B C	-	-	.015	A/B/C
4	01_TOP	Opposite Planes 521	ad23	1.500 ±.005	-.005	1.500	.005	-
5.1	01_TOP	Generic 538	gp1	⌓ .01 A B C	-	-	.01	A/B/C
5.2	01_TOP	Generic 542	gp1	⌓ .01 A B C	-	-	.01	A/B/C

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QIF Overview

Developed and Maintained by the Digital Metrology Standards Consortium (DMSC)

Digital Metrology Standards Consortium DMSC

Learn more!

https://qifstandards.org/

Belcan Blog:

How QIF Can Improve Data Interoperability

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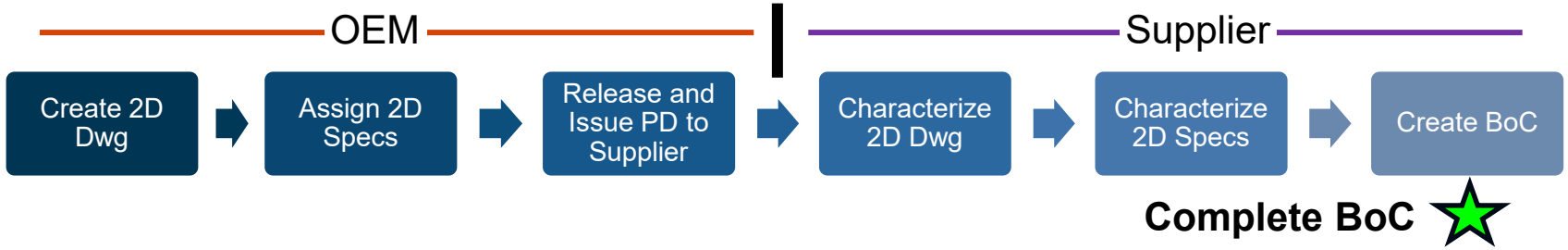
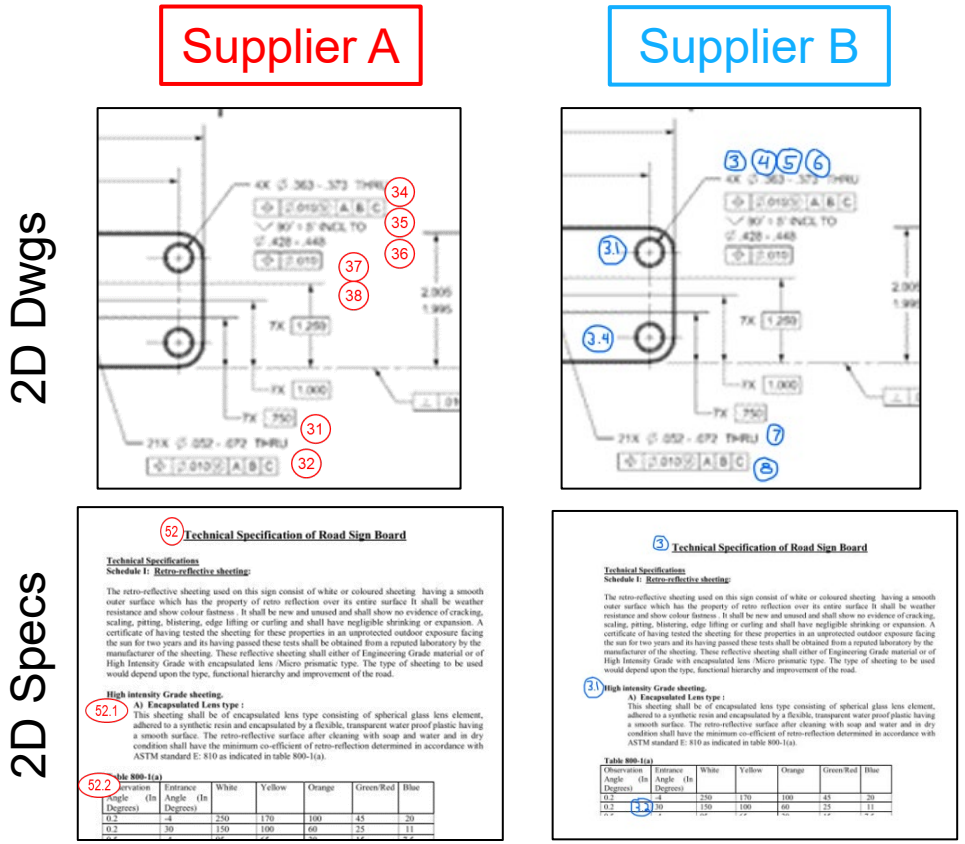
Drawing-Based Characteristics



Suppliers author complete BoC

Gaps to a Digital Thread

- **Single Source of Truth:** Characterization is unique to each supplier
- **Speed:** Time consuming with little automation
- **Quality:** Manual data transcription is error prone
- **Traceability:** Manual effort to align inspection results and req's
- **Interoperability:** BoC does not support machine workflows
- **Consistency:** Characterization is not done to any industry stds



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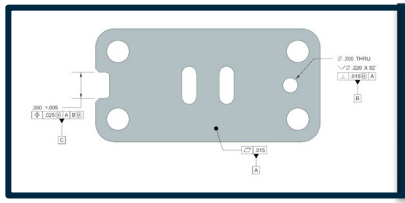
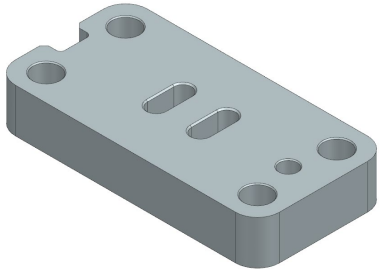
MBD Data Elements



MBD DATA ELEMENTS

Geometry

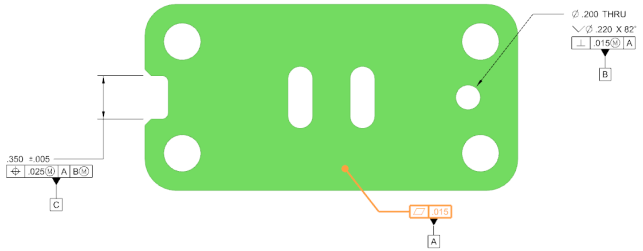
Geometry Definition



Annotations

Explicit Requirements

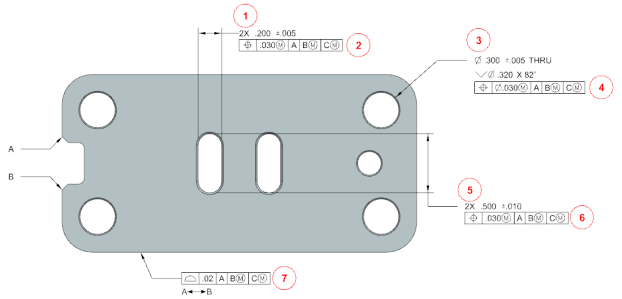
GD&T – Notes – Symbology – Semantic References



*Annotations are also known as Product and Manufacturing Information (PMI)

Characteristic Annotations

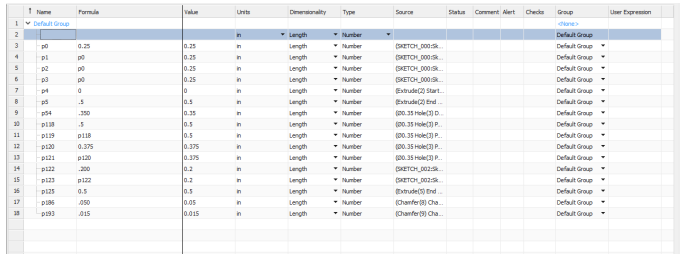
Characteristic Identifiers



Attributes and Parameters

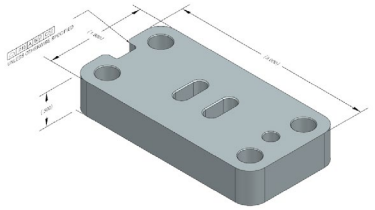
Implicit Requirements

Titleblock Data



Presentation States

Functionally Named Views and States



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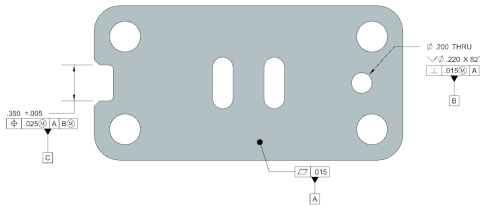
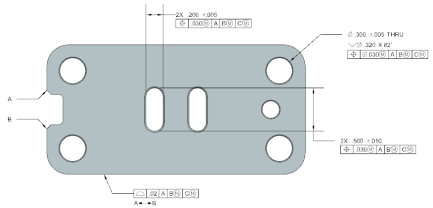


02-BOTTOM



03-TOP

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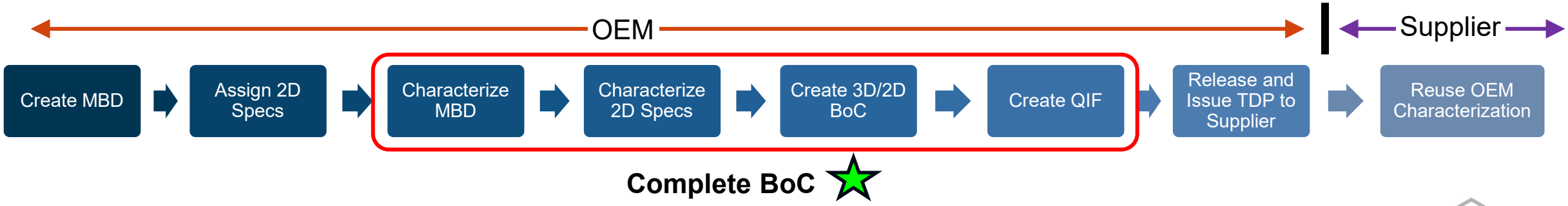
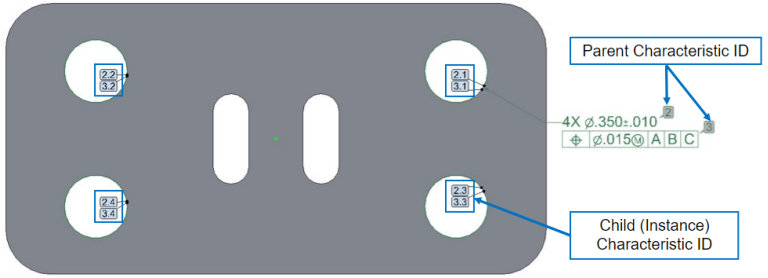
Model-Based Characteristics

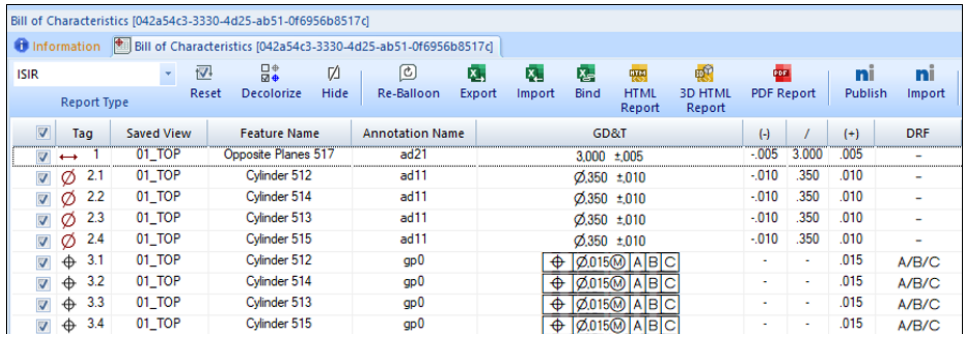


Engineering authors complete BoC

Enabling a Digital Thread

- **Single Source of Truth:** Characterization is authored once in Eng definition
- **Speed:** Automation enabled by machine readable formats
- **Quality:** Software integration replaces manual transcription
- **Traceability:** Unique characteristic IDs persist in digital thread
- **Interoperability:** Characteristics are embedded in interop file format
- **Consistency:** Characteristic authored to industry std format





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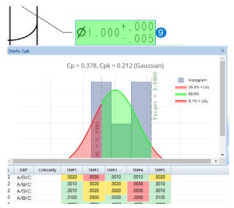
Characteristic Accountability

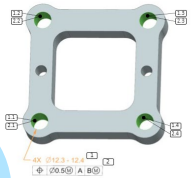
Measurement Results

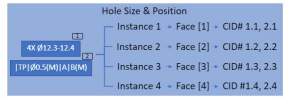
- Inspection results captured and linked to req's in QIF
- SPC and statistical analysis



3D MBD

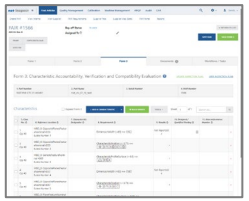
- 3D req's characterized, associated to features
- QIF MBD published for quality workflows





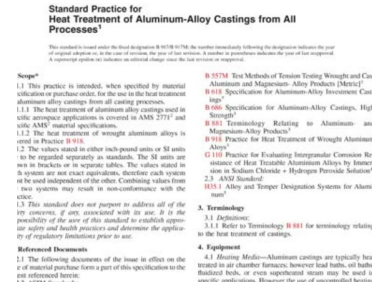
Generate FAIR

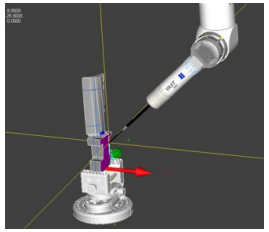
- Complete set of requirements published to quality database



2D Req's

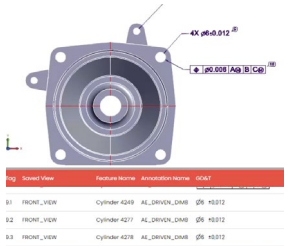
- OCR characterizes 2D req's





Measurement Planning

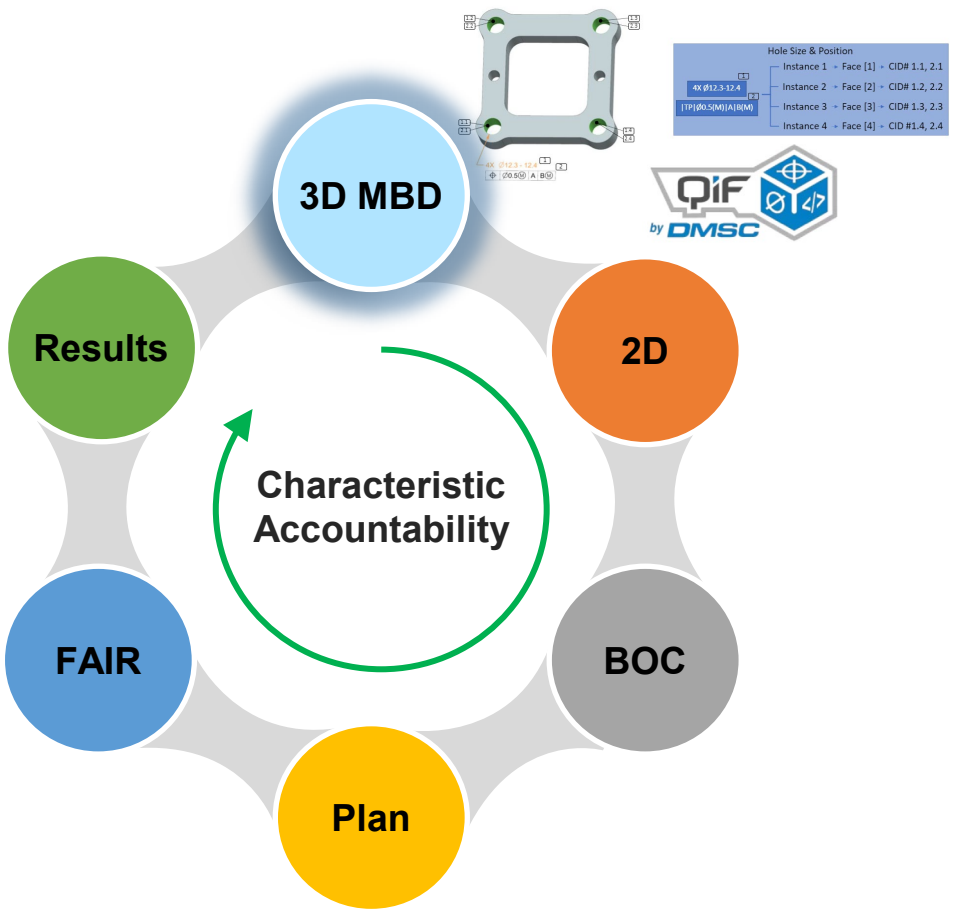
- QIF automates coordinate metrology



Complete BOC

- Unified 3D and 2D req's
- 3D interactive viewer of measurement req's

Characteristic Workflows



3D MBD

- 3D req's characterized, associated to features
- QIF MBD published for quality workflows

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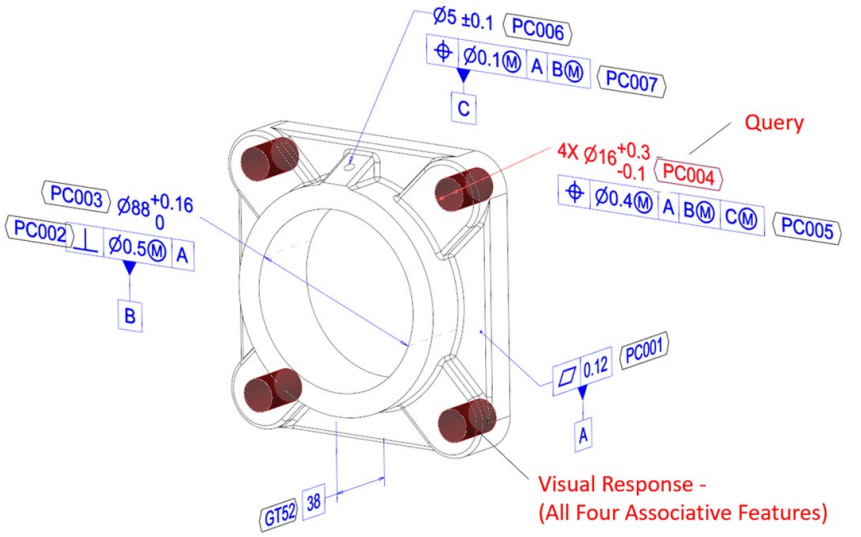
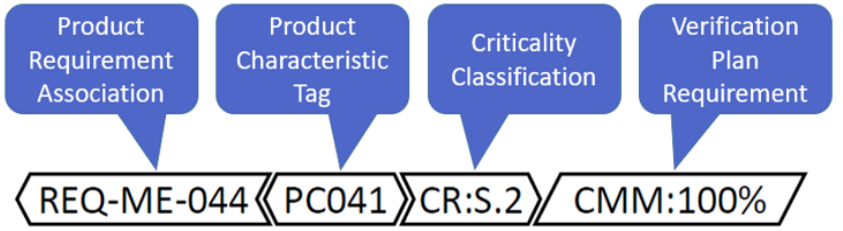
3D MBD – Characteristic Tag

- DMSC's " Model-Based Characteristics" document
- Same organization that manages QIF std
- ~180 page document
- Identifies specific types and categories of product characteristics and optional augmentations
- Nomenclature, definitions, symbols, practice, and data structure for the representation and communication of Model-Based characteristics
- June 2023 – voted to submit document for ANSI std consideration

MODEL-BASED Standard CHARACTERISTICS by DMSC

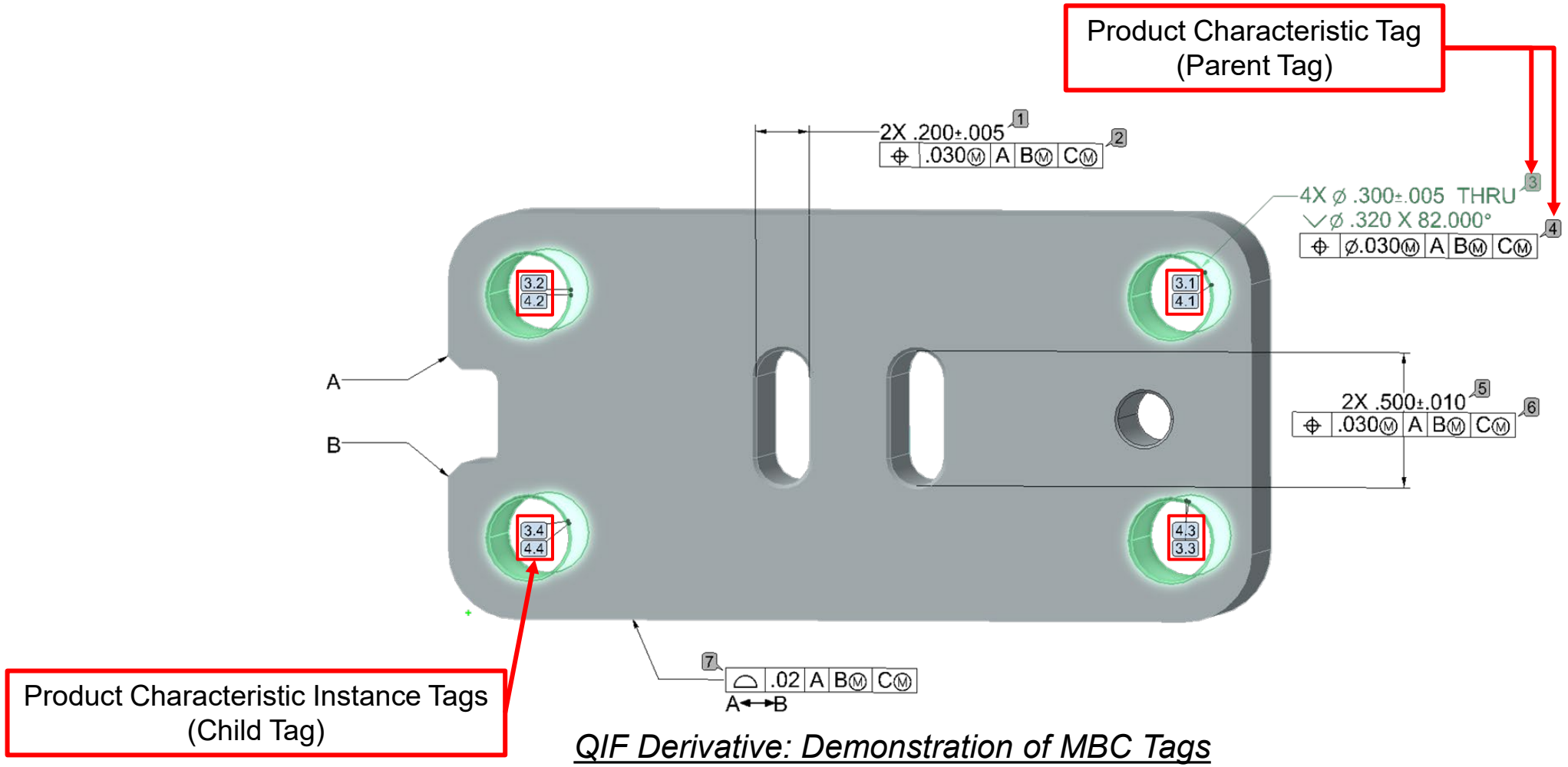
MBC by DMSC





<REQ-ME-044< <PC041> >CR: S.2> /CMM: 100%/

Product Characteristic Tags



QIF Derivative: Demonstration of MBC Tags

Bill Of Characteristics

Bill of Characteristics (BoC)

Bill of Characteristics [4d70ac6e-f771-47b3-b3e3-c33122bcf74d] Universal Unique Identifier (UUID)

AS9102 Report Type | Report Camera | Reset | Decolorize | Hide | Re-Balloon | Export | Import | Bind | HTML Report | 3D HTML Report | PDF Report | Net-Inspect

	Tag	Saved View	Feature Name	Annotation Name	GD&T	(-)	/	(+)	DRF	Criticality
☑	2.1	03-TOP	Opposite Planes 3401	Feature Control Frame (86)	⌖ .030Ⓜ A BⓂ CⓂ	-	-	.030	A/BⓂ/...	
☑	2.2	03-TOP	Opposite Planes 3402	Feature Control Frame (86)	⌖ .030Ⓜ A BⓂ CⓂ	-	-	.030	A/BⓂ/...	
☑	3.1	03-TOP	Cylinder 3415	Radial Dimension (185)	Ø.300 ±.005 THRU ⌵Ø.3...	-.005	.300	.005	–	
☑	3.2	03-TOP	Cylinder 3413	Radial Dimension (185)	Ø.300 ±.005 THRU ⌵Ø.3...	-.005	.300	.005	–	
☑	3.3	03-TOP	Cylinder 3414	Radial Dimension (185)	Ø.300 ±.005 THRU ⌵Ø.3...	-.005	.300	.005	–	
☑	3.4	03-TOP	Cylinder 3412	Radial Dimension (185)	Ø.300 ±.005 THRU ⌵Ø.3...	-.005	.300	.005	–	
☑	4.1	03-TOP	Cylinder 3415	Feature Control Frame (84)	⌖ Ø.030Ⓜ A BⓂ CⓂ	-	-	.030	A/BⓂ/...	
☑	4.2	03-TOP	Cylinder 3413	Feature Control Frame (84)	⌖ Ø.030Ⓜ A BⓂ CⓂ	-	-	.030	A/BⓂ/...	
☑	4.3	03-TOP	Cylinder 3414	Feature Control Frame (84)	⌖ Ø.030Ⓜ A BⓂ CⓂ	-	-	.030	A/BⓂ/...	
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☑	6.1	03-TOP	Elongated Cylinder 3409	Feature Control Frame (94)	⌖ .030Ⓜ A BⓂ CⓂ	-	-	.030	A/BⓂ/...	
☑	6.2	03-TOP	Elongated Cylinder 3410	Feature Control Frame (94)	⌖ .030Ⓜ A BⓂ CⓂ	-	-	.030	A/BⓂ/...	
☑	7	03-TOP	Generic 3439	Feature Control Frame (87)	⌓ .02 A BⓂ CⓂ A...	-	-	.02	A/BⓂ/...	
☑	8	02-BOTTOM	Group 3441	Radial Dimension (115)	Ø .200 THRU ⌵Ø .220...	-.005	.200	.005	–	

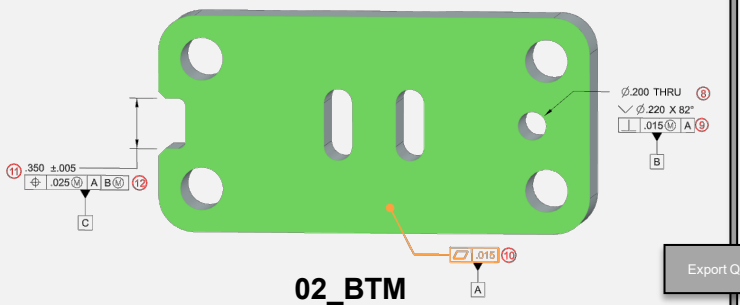
- Characteristic IDs
- Presentation State
- Measurement Object
- Product and Manufacturing Information (PMI)
- Datum Reference Frame (DRF)

QIF Export - MBD Data Elements

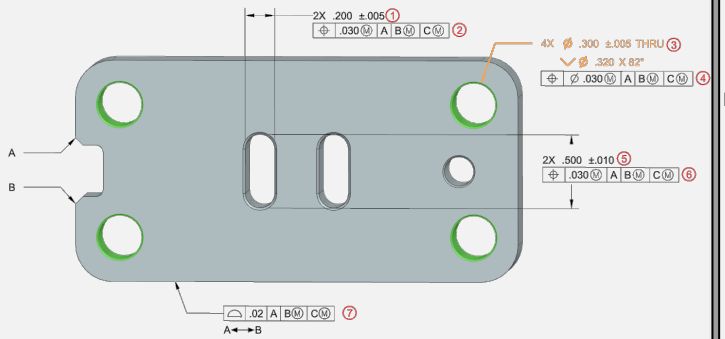
Native CAD System

SIEMENS NX

- Source 3D MBD CAD
- Machine/Software-Readable



02_BTM



03_TOP

Export QIF

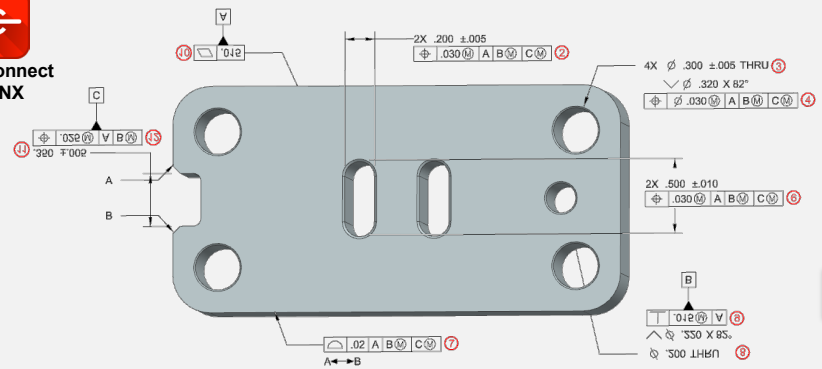
QIF Export

QIF by DMSC

Harvesting Source CAD MBD Elements:

- Geometry
- Annotation
- Characteristics
- Presentation States
- Attributes

MBDConnect for NX



Bill Of Characteristics (BoC)

MBDVidia

Bill of Characteristics [e16c412c-db40-4483-aa03-0b8e19ff8a04]

AS9102 — Report Type | Report Camera | Reset | Decolorize | Hide | Re-Balloon | Export | Import | Bind | HTML Report | 3D HTML Report | PDF Report | Publish

	Tag	Saved View	Feature Name	Annotation Name	GD&T	(-)	/	(+)	DRF	Critic
☑	1.1	03-TOP	Opposite Planes 1830	Linear Dimension (85)	.200 ±.005	-.005	.200	.005	-	
☑	1.2	03-TOP	Opposite Planes 1831	Linear Dimension (85)	.200 ±.005	-.005	.200	.005	-	
☑	2.1	03-TOP	Opposite Planes 1830	Feature Control Frame (86)	.030 Ⓜ A B Ⓜ C Ⓜ	-	-	.030	A/B Ⓜ/_	
☑	2.2	03-TOP	Opposite Planes 1831	Feature Control Frame (86)	.030 Ⓜ A B Ⓜ C Ⓜ	-	-	.030	A/B Ⓜ/_	
☑	3.1	03-TOP	Group 1857	Radial Dimension (120)	Ø .300 ±.005 THRU	-.005	.300	.005	-	
☑	3.2	03-TOP	Group 1853	Radial Dimension (120)	Ø .300 ±.005 THRU	-.005	.300	.005	-	
☑	3.3	03-TOP	Group 1855	Radial Dimension (120)	Ø .300 ±.005 THRU	-.005	.300	.005	-	
☑	3.4	03-TOP	Group 1851	Radial Dimension (120)	Ø .300 ±.005 THRU	-.005	.300	.005	-	
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☑	4.2	03-TOP	Group 1853	Feature Control Frame (84)	Ø.030 Ⓜ A B Ⓜ C Ⓜ	-	-	.030	A/B Ⓜ/_	
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☑	5.1	03-TOP	Elongated Cylinder 1838	Linear Dimension (93)	.500 ±.010	-.010	.500	.010	-	
☑	5.2	03-TOP	Elongated Cylinder 1839	Linear Dimension (93)	.500 ±.010	-.010	.500	.010	-	
☑	6.1	03-TOP	Elongated Cylinder 1838	Feature Control Frame (94)	.030 Ⓜ A B Ⓜ C Ⓜ	-	-	.030	A/B Ⓜ/_	
☑	6.2	03-TOP	Elongated Cylinder 1839	Feature Control Frame (94)	.030 Ⓜ A B Ⓜ C Ⓜ	-	-	.030	A/B Ⓜ/_	

Validate QIF

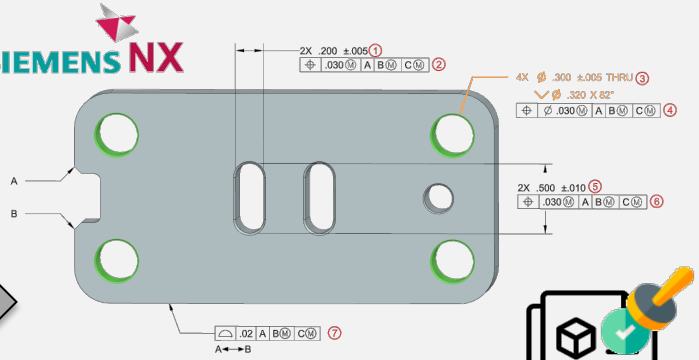
Validate QIF Translation

CIV

- CompareVidia Tool
- Validate QIF back to Source CAD

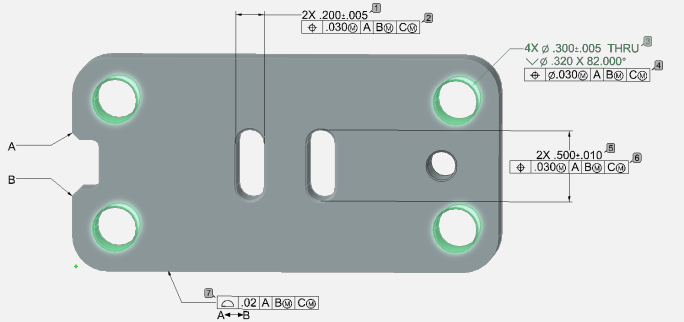
CAPVIDIA

SIEMENS NX



CAD Validated

QIF by DMSC



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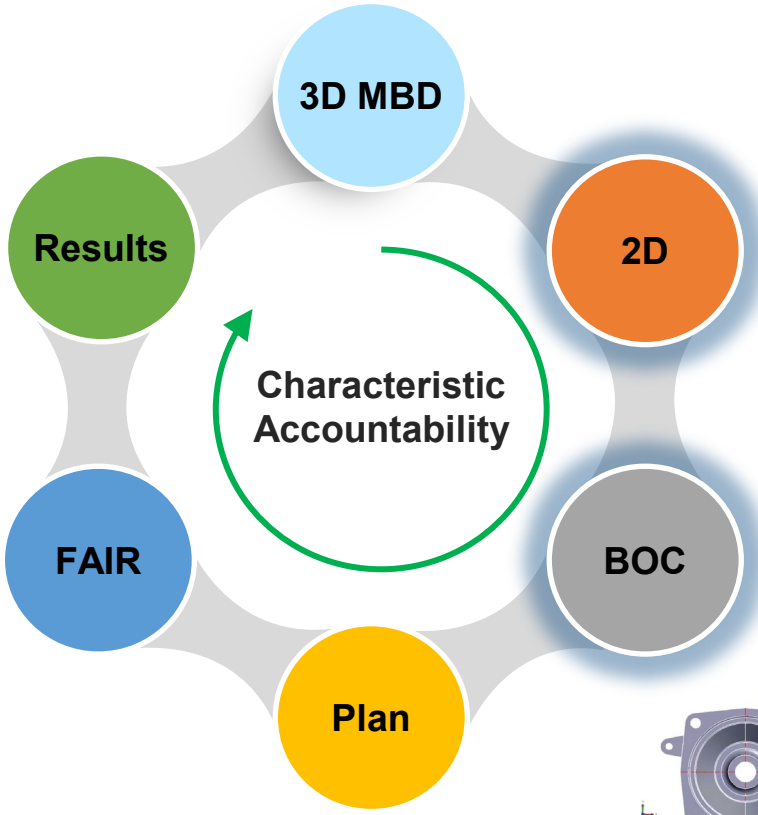
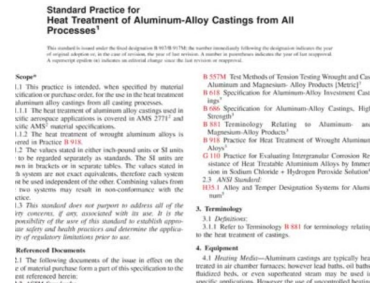
Characteristic Workflows



2D Req's

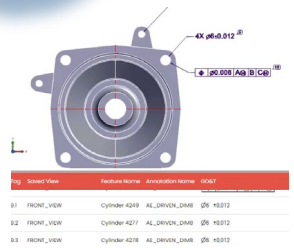
- OCR characterizes 2D req's



Standard Practice for
Heat Treatment of Aluminum-Alloy Castings from All Processes[1]

Complete BOC

- Unified 3D and 2D req's
- 3D interactive viewer of measurement req's

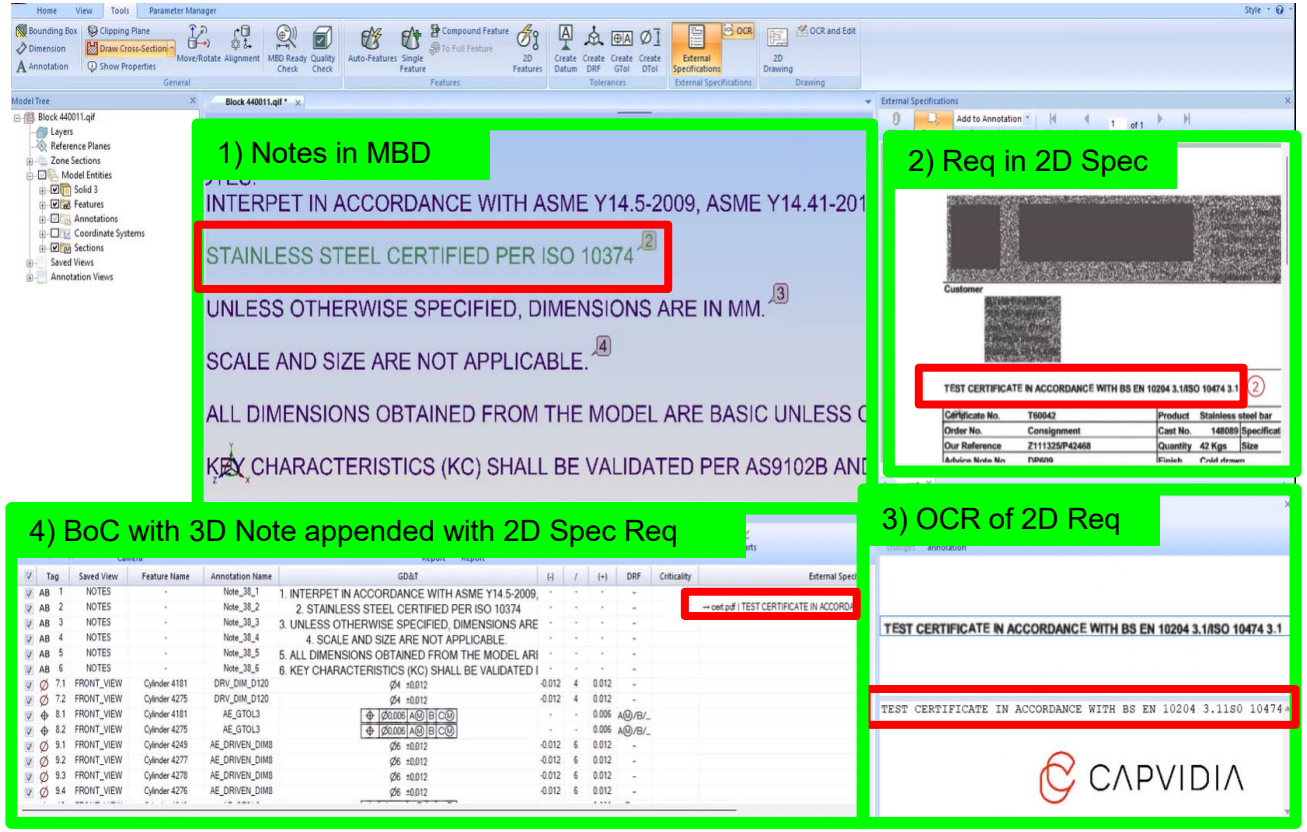


2D PDF and Complete BoC

Example Workflow to a Complete BoC

1. Example has PMI general note that references an ISO std req contained in a 2D spec
2. 2D spec characterized with software
3. OCR is used to pull text into software
4. 2D req is appended to 3D general note in BoC

Capvidia MBDVidia Software



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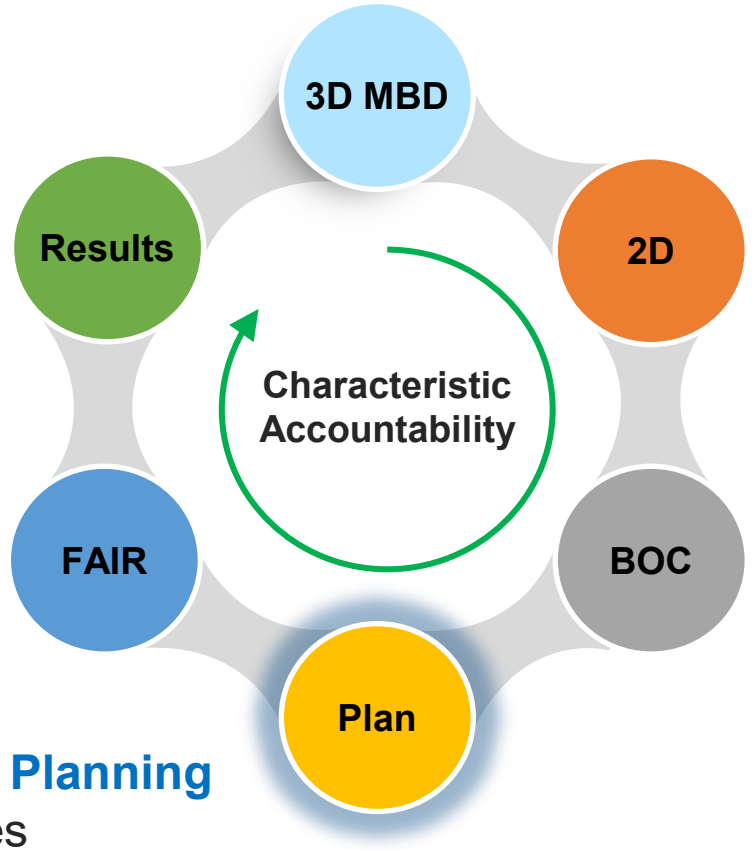
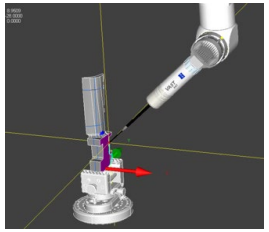
Characteristic Workflows



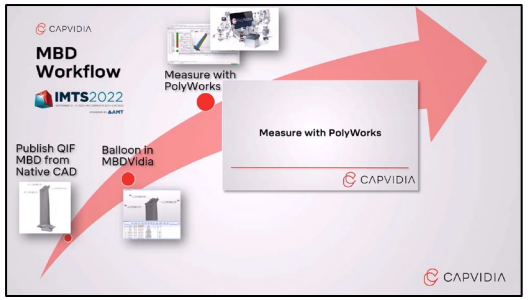


Measurement Planning

- QIF automates coordinate metrology

QIF – Measurement Planning

Video



QIF Derivative

CAPVIDIA

QIF by DMSC

MBDVidia

Inspection Plan

PolyWorks® By InnovMetric Software Inc.

Enabling a Digital Thread

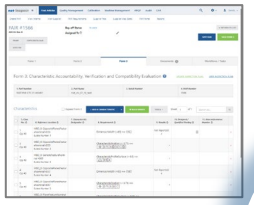
Single Source of Truth, Speed, Quality, Traceability, Interoperability, Consistency

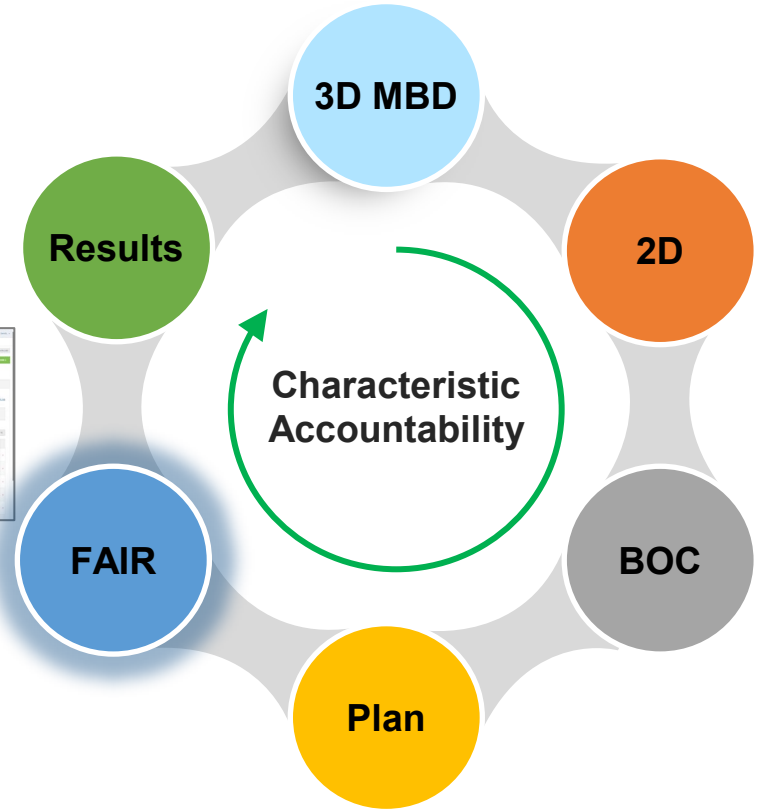
Capvidia. (September 26th, 2022). *IMTS 2022 Workflow with QIF MBD.* https://www.youtube.com/watch?app=desktop&v=VYoqZXQ2X7M

Characteristic Workflows

Generate FAIR

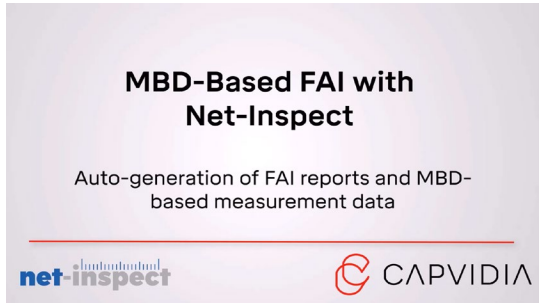
- Complete set of requirements published to quality database





QIF – FAIR

Video



QIF Derivative

CAPVIDIA

MIV

MBDVidia

FAIR Characteristic List

net-inspect

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Capvidia. (September 26th, 2022). *MBD First Article Inspection Reporting with QIF & Net-Inspect* https://www.youtube.com/watch?v=XtZ075ZyB2k

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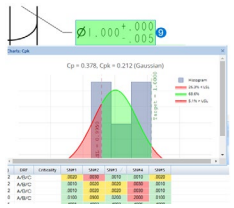
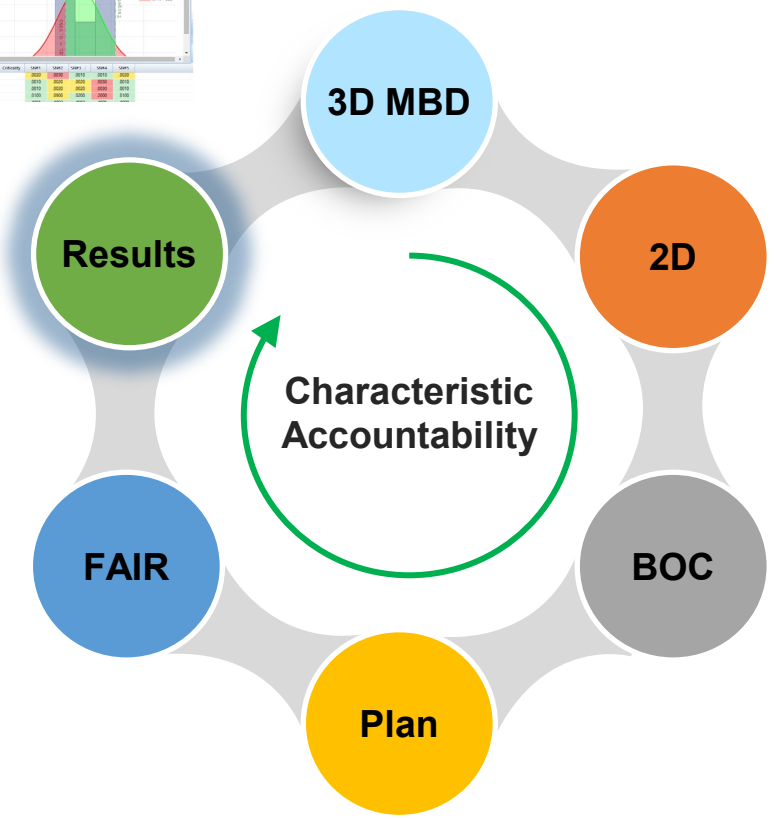
Characteristic Workflows

Measurement Results

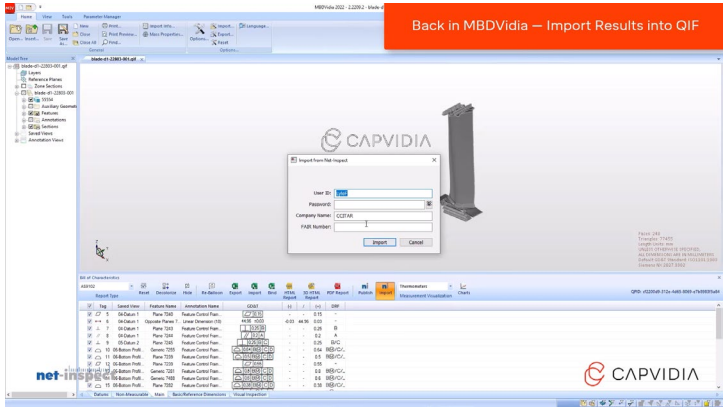
- Inspection results captured and linked to req's in QIF
- SPC and statistical analysis





QIF – Measurement Results (Net-Inspect)

Video



QIF Results

net-inspect

QIF by DMSC

Measurement Analysis

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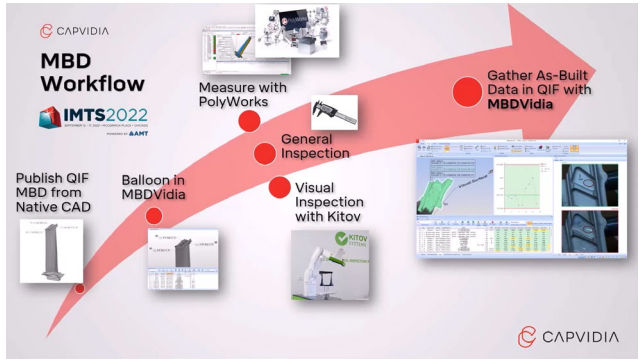
Capvidia. (September 26th, 2022). *IMTS 2022 Workflow with QIF MBD.* https://www.youtube.com/watch?app=desktop&v=VYoqZXQ2X7M

QIF – Measurement Results (Excel)

Video



QIF Results

PolyWorks® By InnovMetric Software Inc.

QIF by DMSC

Measurement Analysis

CAPVIDIA

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Capvidia. (September 26th, 2022). *IMTS 2022 Workflow with QIF MBD.* https://www.youtube.com/watch?app=desktop&v=VYoqZXQ2X7M

How QIF Can Improve Data Interoperability

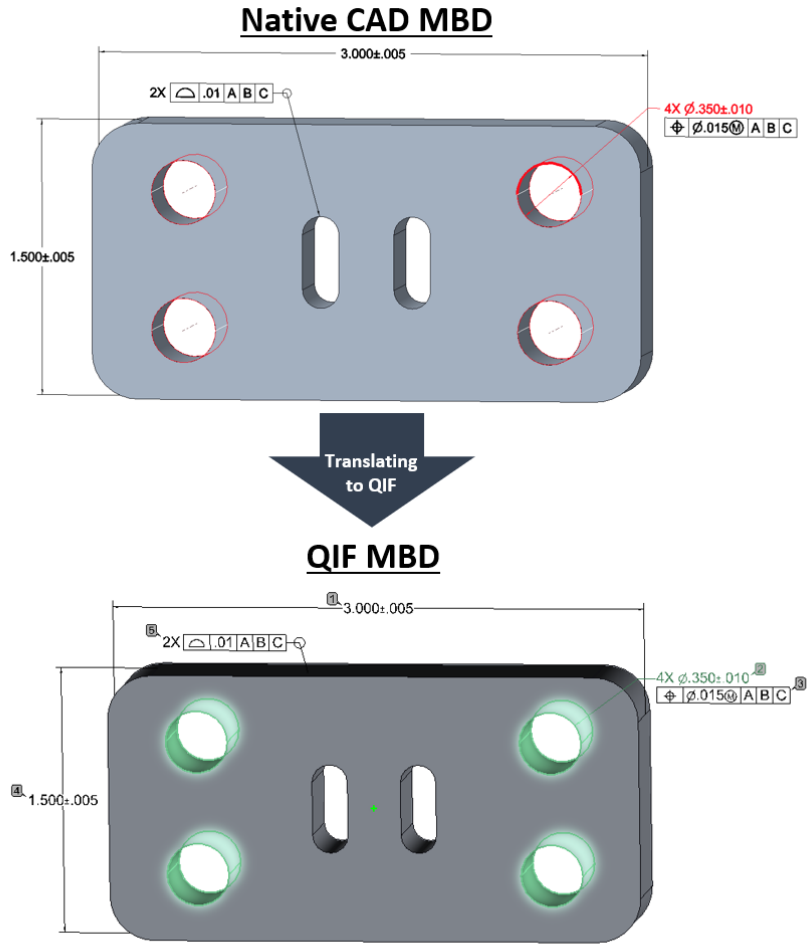

Figure 1: Native MBD Translated to QIF, Harvesting All the Native MBD Elements

Belcan Blog: [How QIF Can Improve Data Interoperability](#)

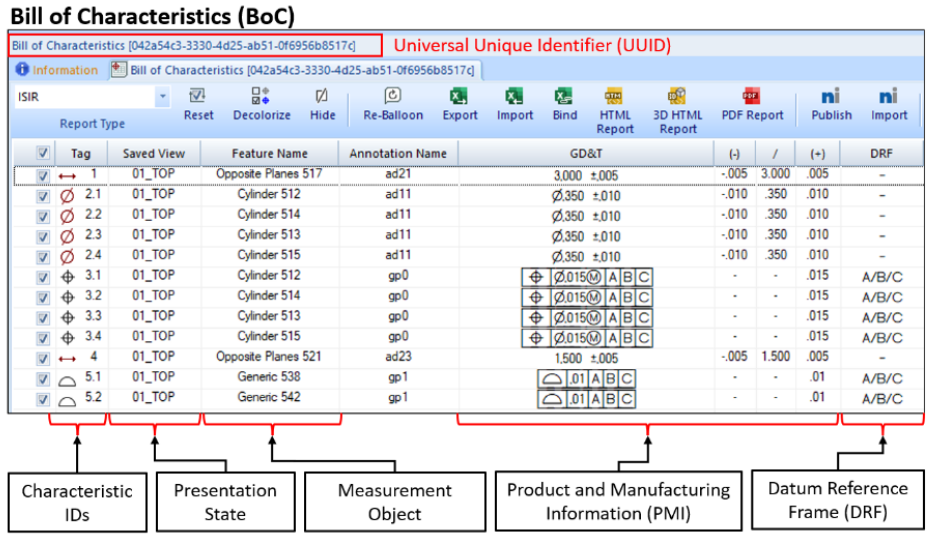

Figure 4: Characterized Bill of Characteristics (BoC)

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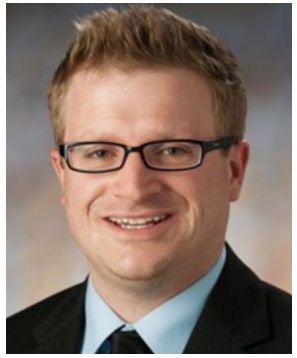
Starting your Transformational Journey

What Foundational Elements are Needed to Support a Digital Thread?

- Shift Characterization Left
- Author a Complete BoC
- Leverage Industry Standards
- Work with trusted SMEs



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Thank You For Participating!