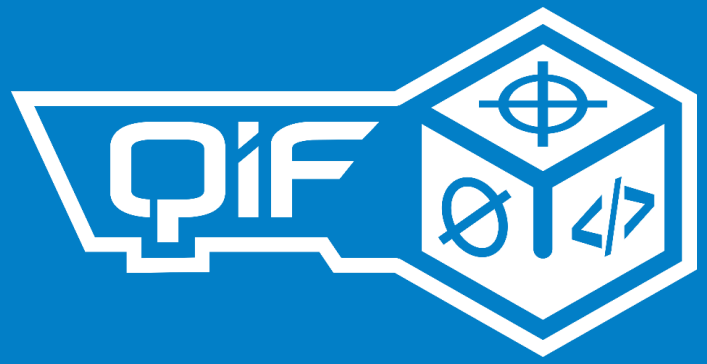

DMSC
Digital Metrology Standards Consortium

QIF Overview

Daniel Campbell
VP Model-Based Definition, Capvidia
Chair, QIF Working Group
Member, Board of Directors, DMSC

April 18, 2024
MBE/QIF Summit – MxD Chicago

About the DMSC
Digital Metrology Standards Consortium

- A non-profit, cooperative sponsorship, consortium organization since 1983.
- Dedicated to identifying, promoting, fostering, and encouraging the development and interoperability of information standards that benefit the digital metrology community.
- Preparing standards that impact digital model-based quality enterprise.
- A professional group of manufacturing metrologists, software developers, and innovators worldwide. Note: 500+ years of experience contributed to the QIF.
- Maintainers of Dimensional Measuring Interface Standard (DMIS) standard.
- Developers & maintainers of Quality Information Framework (QIF) standard.
- Developers & maintainers of Model Based Characteristics (MBC) standard.
- ANSI accredited standards making organization
- A-Liaison member of ISO / TC 184 / SC 4 (allows for harvesting ANSI standards)

DMSC Members

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DMSC
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Daniel Campbell Capvidia	**Rosemary Astheimer** Purdue University

Why Join the DMSC?

Influence the standards

Do your part for interoperability

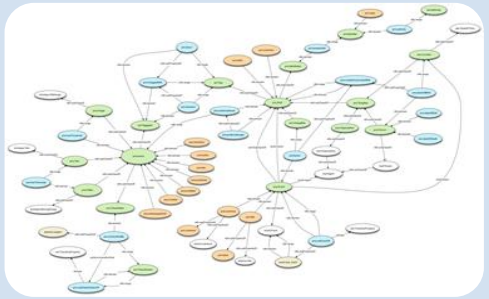
Connect with likeminded tech enthusiasts

Visit www.qifstandards.org for more information

QIF Overview

What is QIF?

What is QIF?



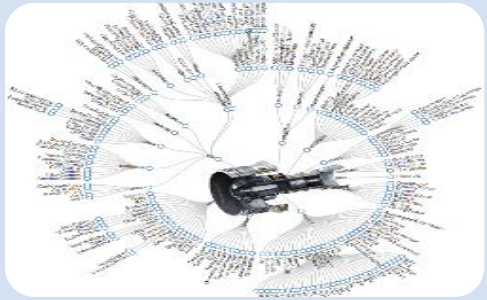
Characteristic-Centric, Feature-Based Ontology of Manufacturing Quality Metadata

Structured Data

< />

XML Technology: Simple, Modern Implementation with Built-In Code Validation

Modern Approach



Semantically Linked to MBD for Traceability

Connected Data

ISO

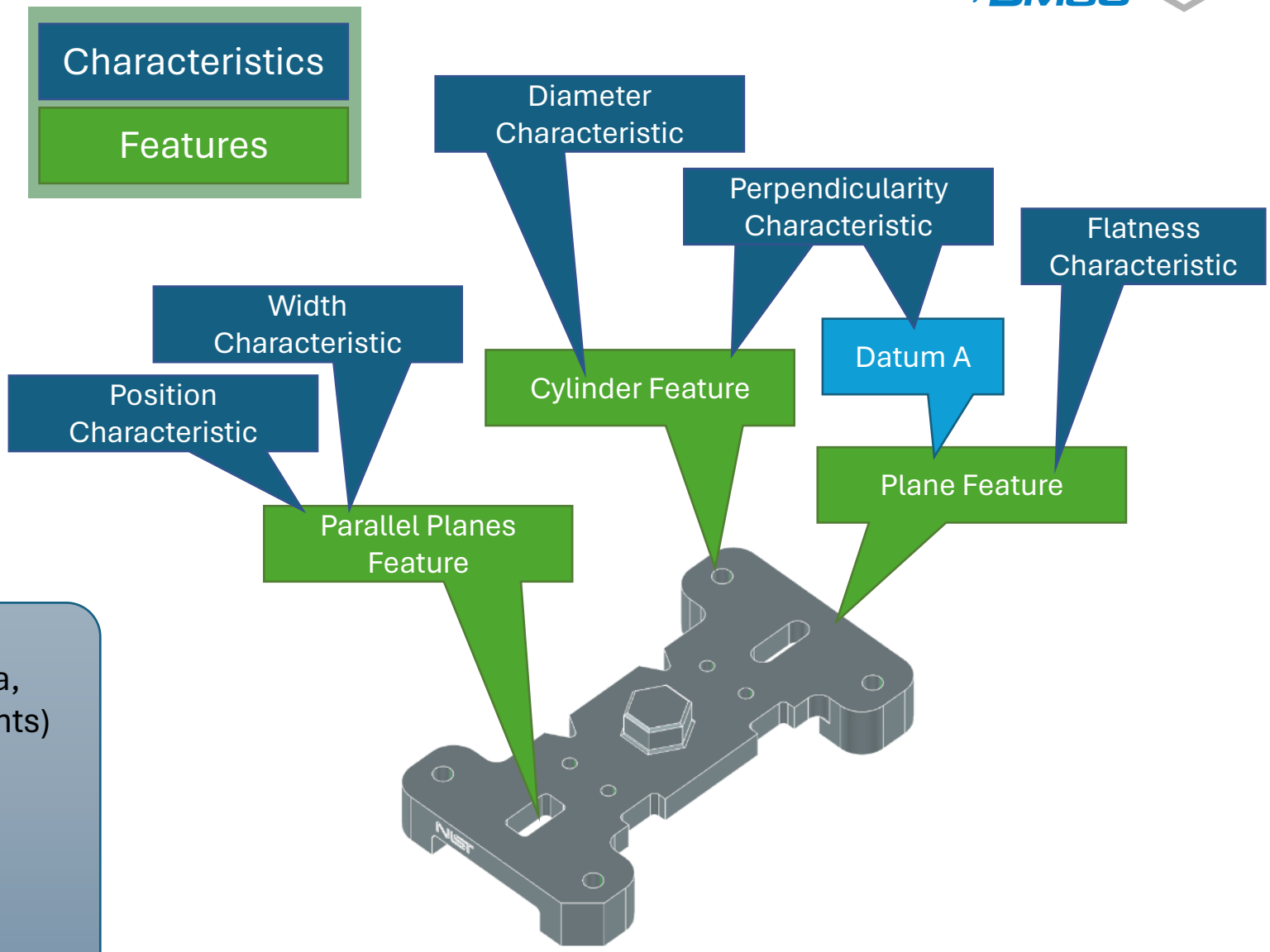
ISO Standard for interoperability

Standard Artifacts

The Building Blocks of QIF: **Features & Characteristics**

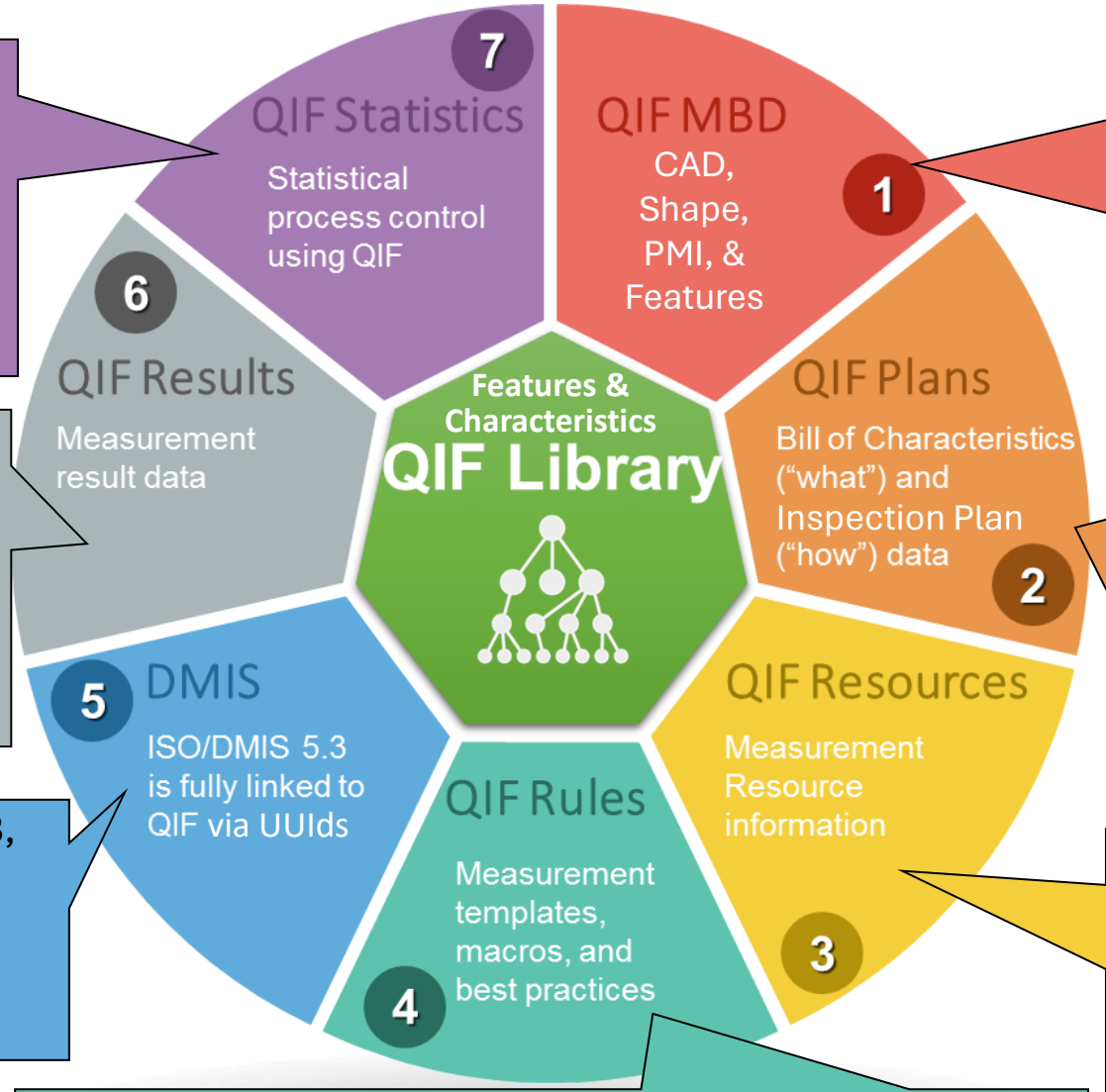
Model geometry is wrapped by **Features**
- Different concept than CAD features!
- Sometimes referred to as:
  - Tolerance Features
  - Metrology Features
  - Measurement Features

Features are referenced by **Characteristics** (aka, Product Characteristics, Inspection Requirements)
- Geometric Tolerances
- Dimensional Tolerances
- Specifications
- Notes
- Welds
- Etc.



QIF Application Areas

Reference a bundle of QIF Results sets and specify a statistical analysis method to be carried out. Can optionally include the results of the statistical analysis as well



QIF MBD (Model-Based Definition) is the basis for providing traceability to authority CAD data. It is not required for basic QIF use cases.

Measurement results data, associated with the MBD! This can be just tolerance evaluation results and can even include all the point cloud data from the features.

Wide range of optional levels of detail for measurement plans:

- What to Measure: Bill of Characteristics
- How to Measure: Inspection Plan
- Assign measurement resources
- Specify sampling point locations

DMIS is <u>not</u> part of QIF, ISO 22093, however the latest ANSI DMIS 5.3 has been updated to harmonize with the data traceability mechanisms in QIF.

Specify basic or highly detailed information about available measurement equipment (e.g., CMMs, probes, calipers, gages). As always, this data is contextual and semantic.

Rule templates for creating measurement rule instances. (e.g., *If a Surface Profile tolerance value is less than **x**, then use a CMM method with at least **y** number of point/sq.in.)*

QIF Core

The primary technological details to be aware of

Major QIF Elements
QIF Document

- Top level container for an instance file
  - 1 instance file = 1 QIFDocument
- At the top level, it contains all the key elements we will discuss in the next slides
- Almost all the elements at this level are optional

```
<QIFDocument>

    ...

    <Header> ... </Header>

    <DatumDefinitions> ... /DatumDefinitions>

    <DatumReferenceFrames> ... </DatumReferenceFrames>

    <MeasurementResources> ... </MeasurementResources>

    <Product> ... </Product>

    <Features> ... </Features>

    <Characteristics> ... </Characteristics>

    <Results> ... </Results>

</QIFDocument>
```

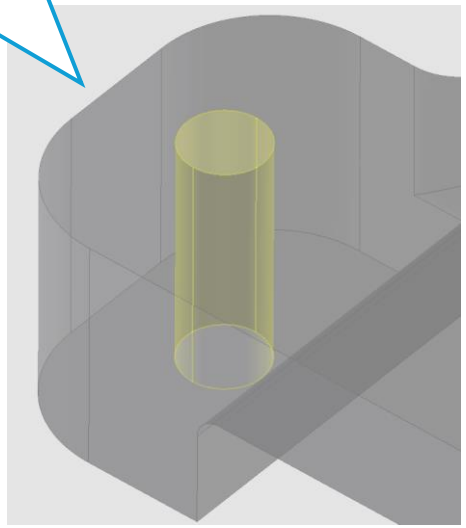
Major QIF Elements
Library: Features

An abstraction for referencing a portion of a part.
In MBD, this means:
A container for referencing one or more geometrical entities on the model

There are lots of feature types! Some examples:

- Cylinder
- Plane
- Cone
- Opposite Parallel Planes (slot)
- Freeform (generic)
- Circles
- Lines
- Ellipse
- Compound Features
- Pattern Features
- Etc.

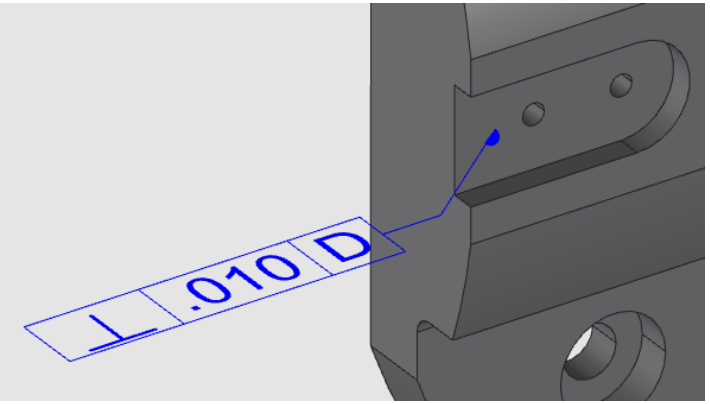
This Cylinder feature is made up of 2 CAD surfaces. (Pretty typical.) But the CAD's mathematical representation of this geometry is irrelevant – this is a functional hole, and needs to be treated as such!



Major QIF Elements
Library: Characteristics

A control placed on a Feature.

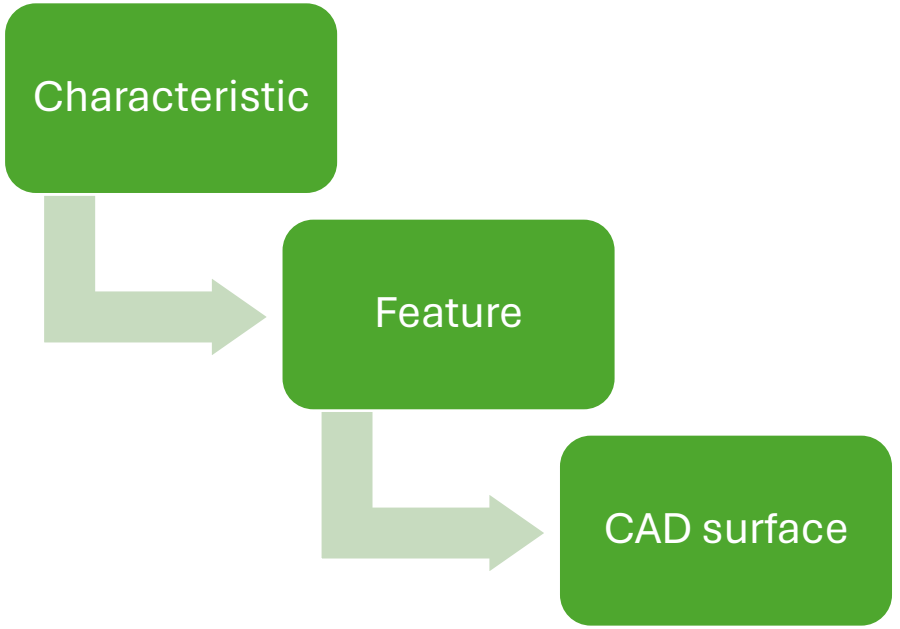
For example, a Size/Form/Orientation/Location tolerance, a Surface Finish, a Weld specification, etc.



With QIF MBD, it is also possible for a Characteristics to have a 3D presentation element (e.g., an annotation). But that's for human consumption.

How is a Characteristic connected to the MBD?

A Characteristic points to a Feature, and a Feature points to CAD geometry.



The Building Blocks of QIF: **Features & Characteristics**

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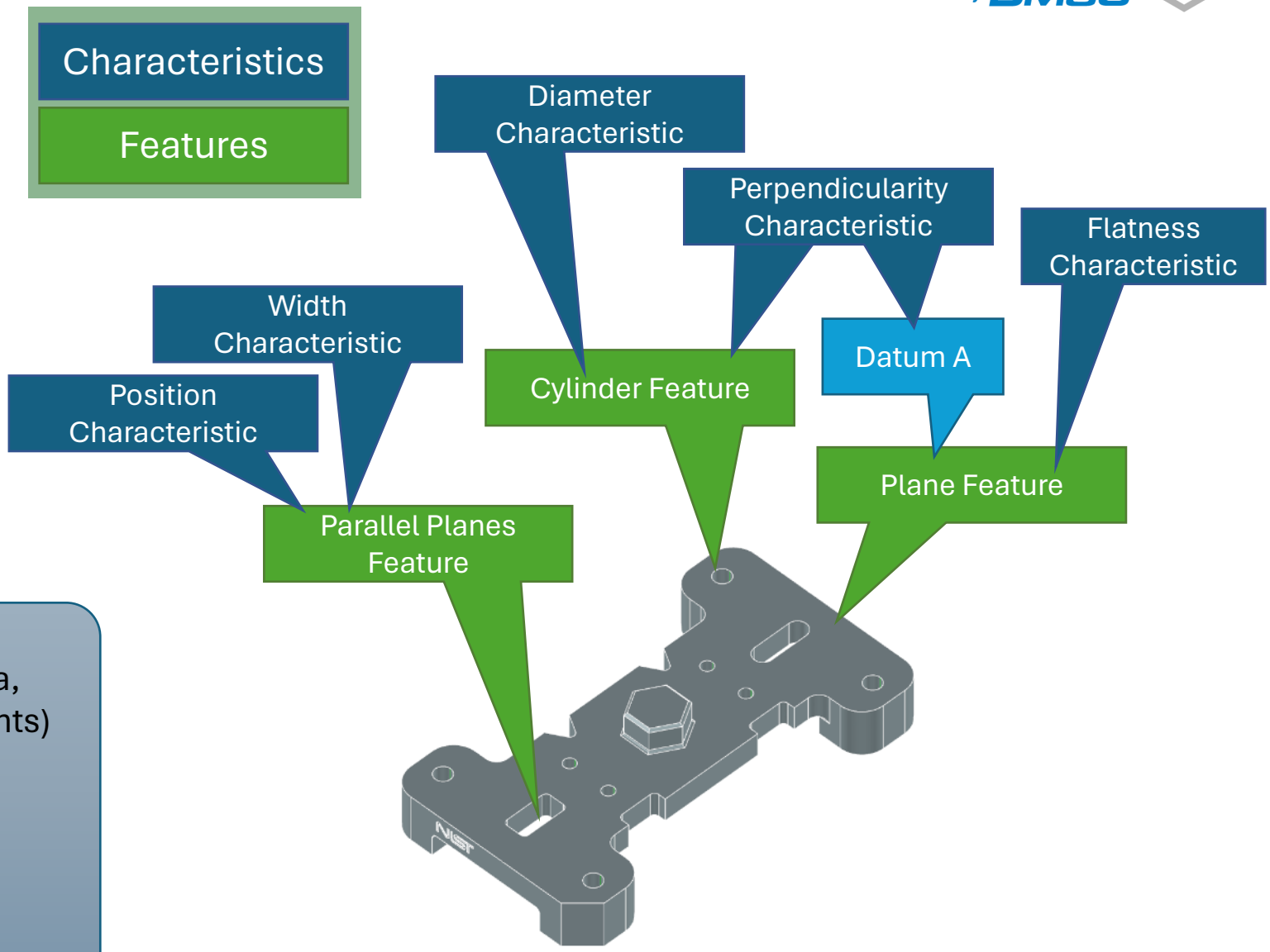
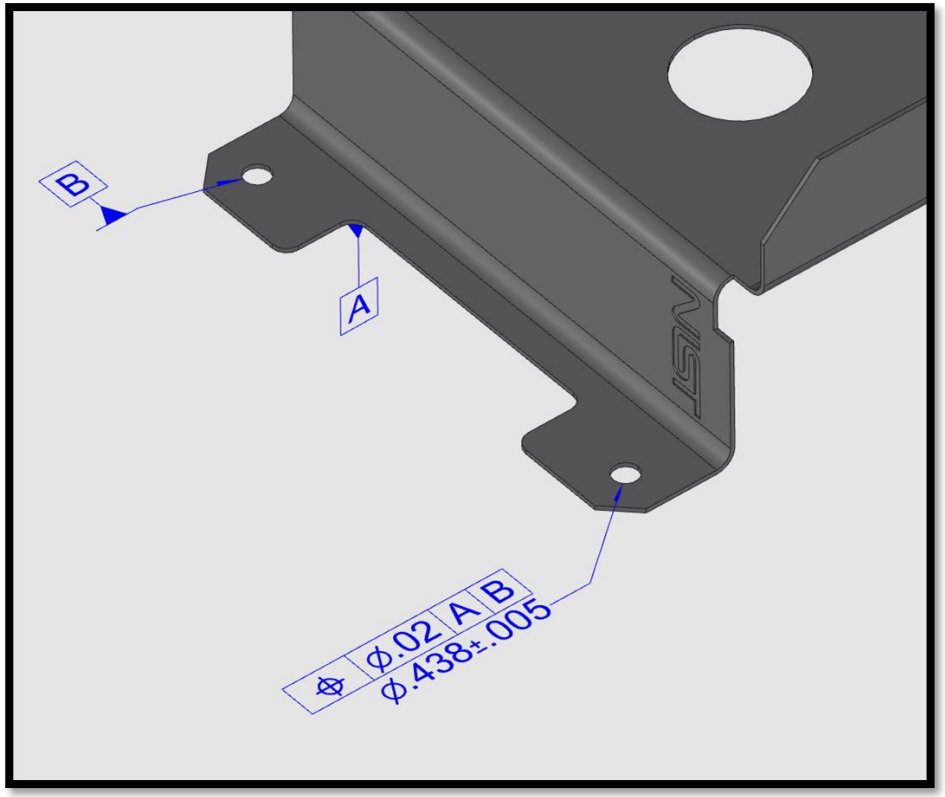


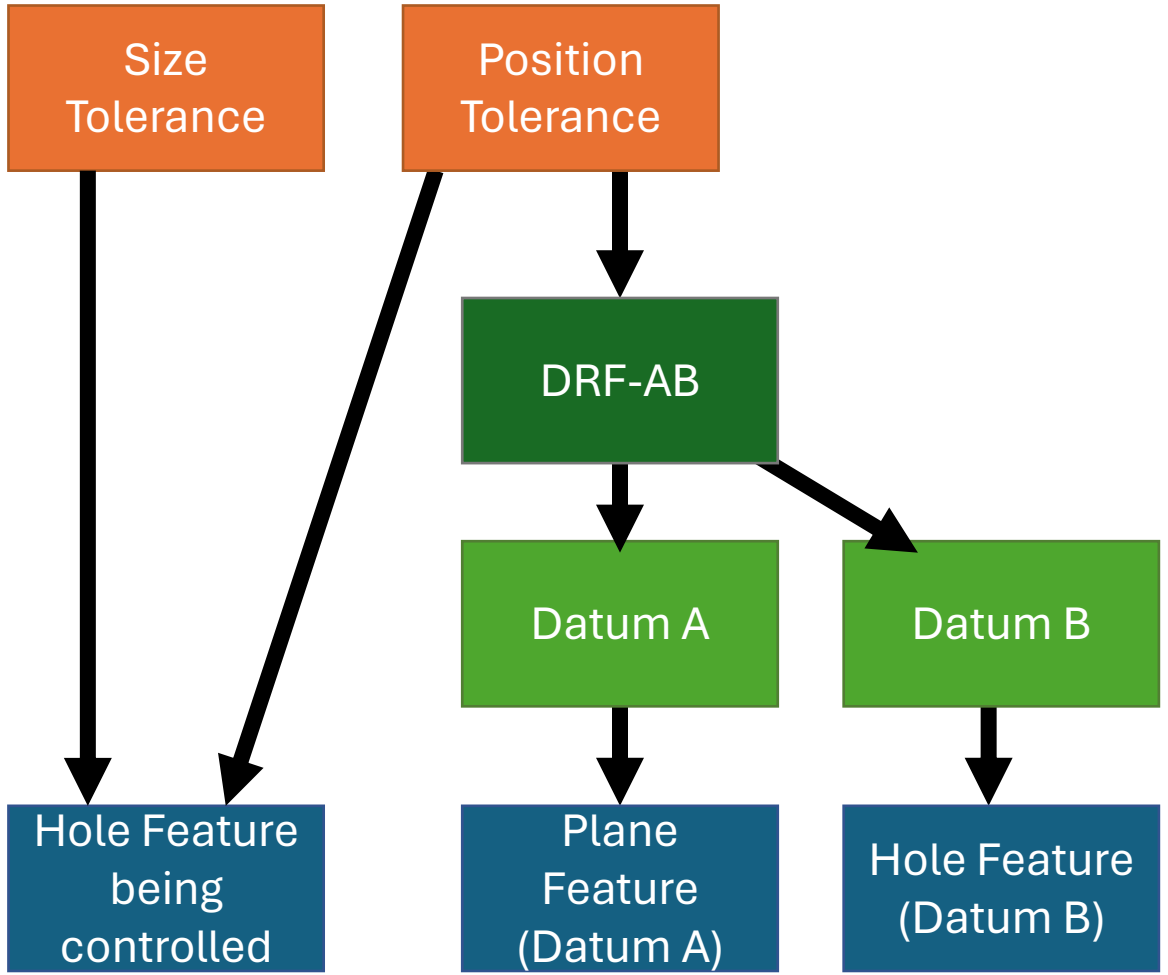
QIF – The Details

The nitty gritty details for the real nerds ☺

Major QIF Elements
Library: Datums and DRFs

Datums and DRFs are data structures used to help define the geometric controls implied by a GTol. This is how Features, Datums Features, and GTols are linked.



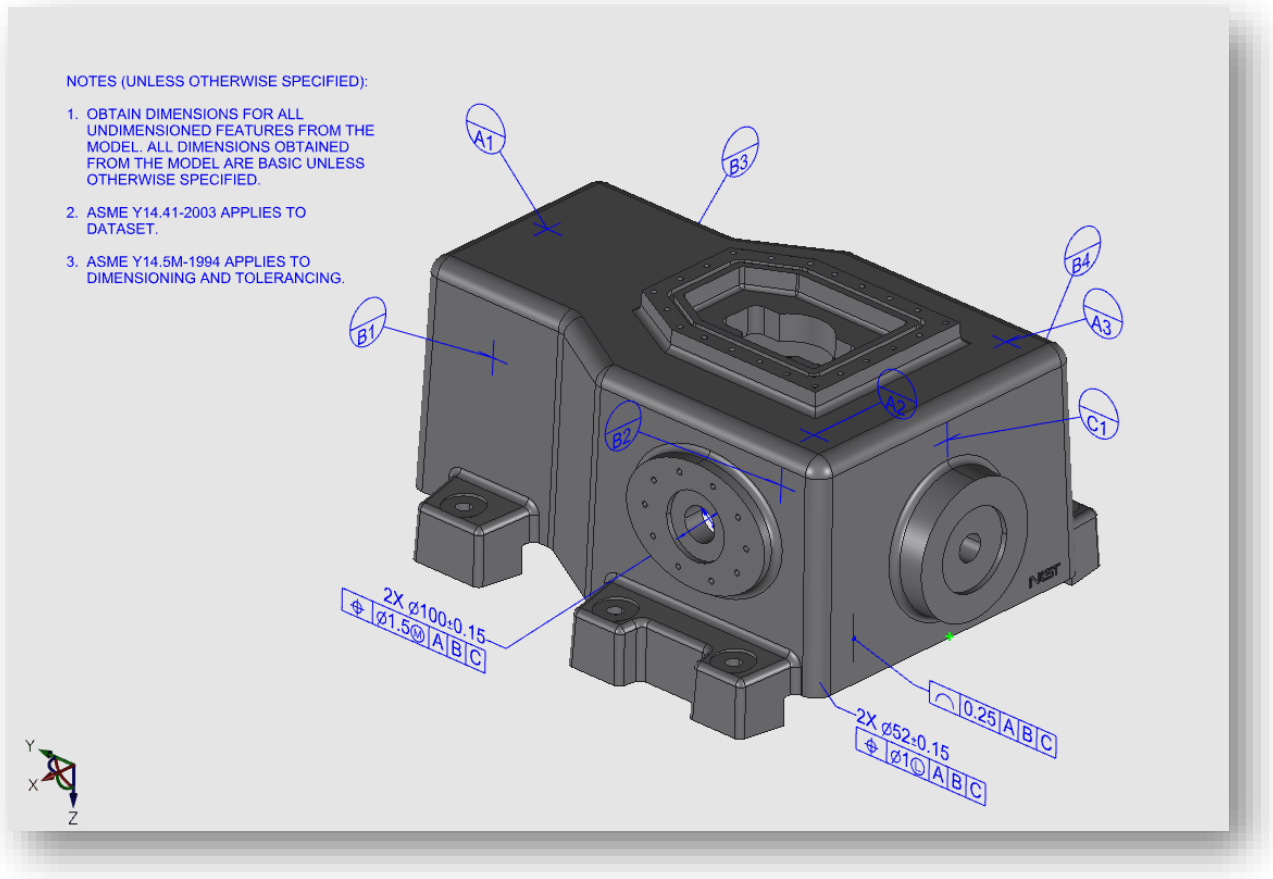


Major QIF Elements
Applications: Product (aka, MBD)

The “Product” is the name of the element for QIF MBD data.

This is how Feature & Characteristic Nominals and Feature & Characteristic Measurements are tied to the MBD model.

This is how **Digital Twin** is done.

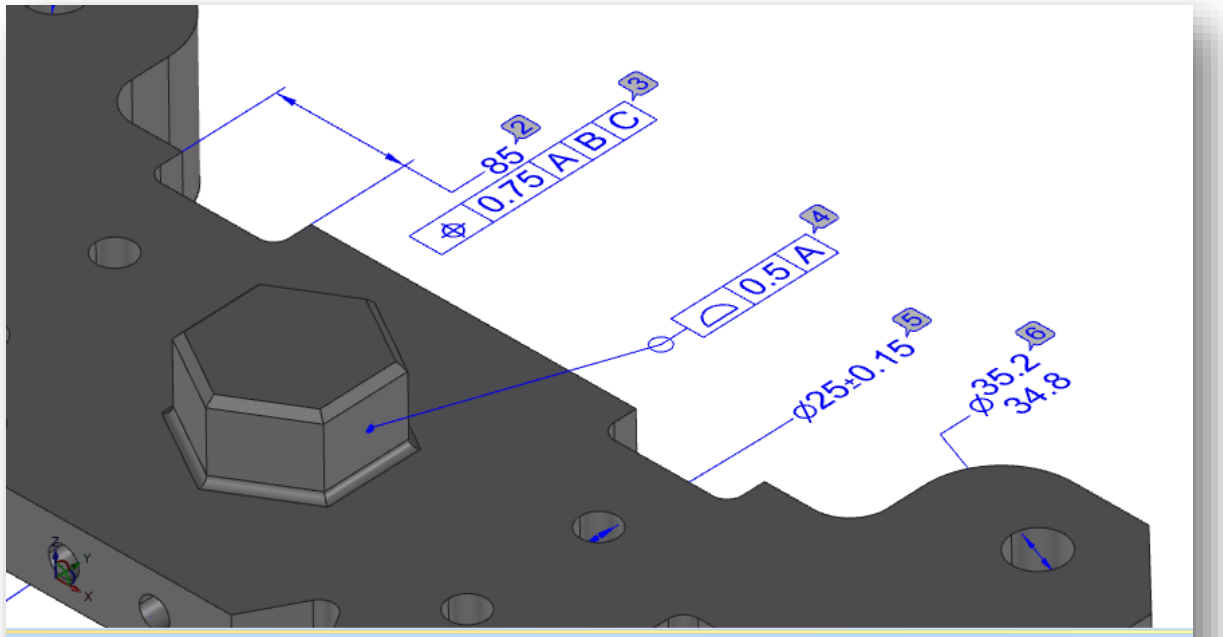


Major QIF Elements
Applications: Plans

Measurement Plans can be described in various levels of detail. Can range anywhere between:

High level plan: just the Bill of Characteristics – *what is being measured*?

Detailed plan: What is being measured, what equipment is being used to do it, where are sampling points being taken, etc.



Bill of Characteristics

AS9102 | Report Type | Reset | Decolorize | Re-Balloon | Export | Import | Bind | HTML Report | PDF Report | Publish | Import | Thermometers | Measurement Vis

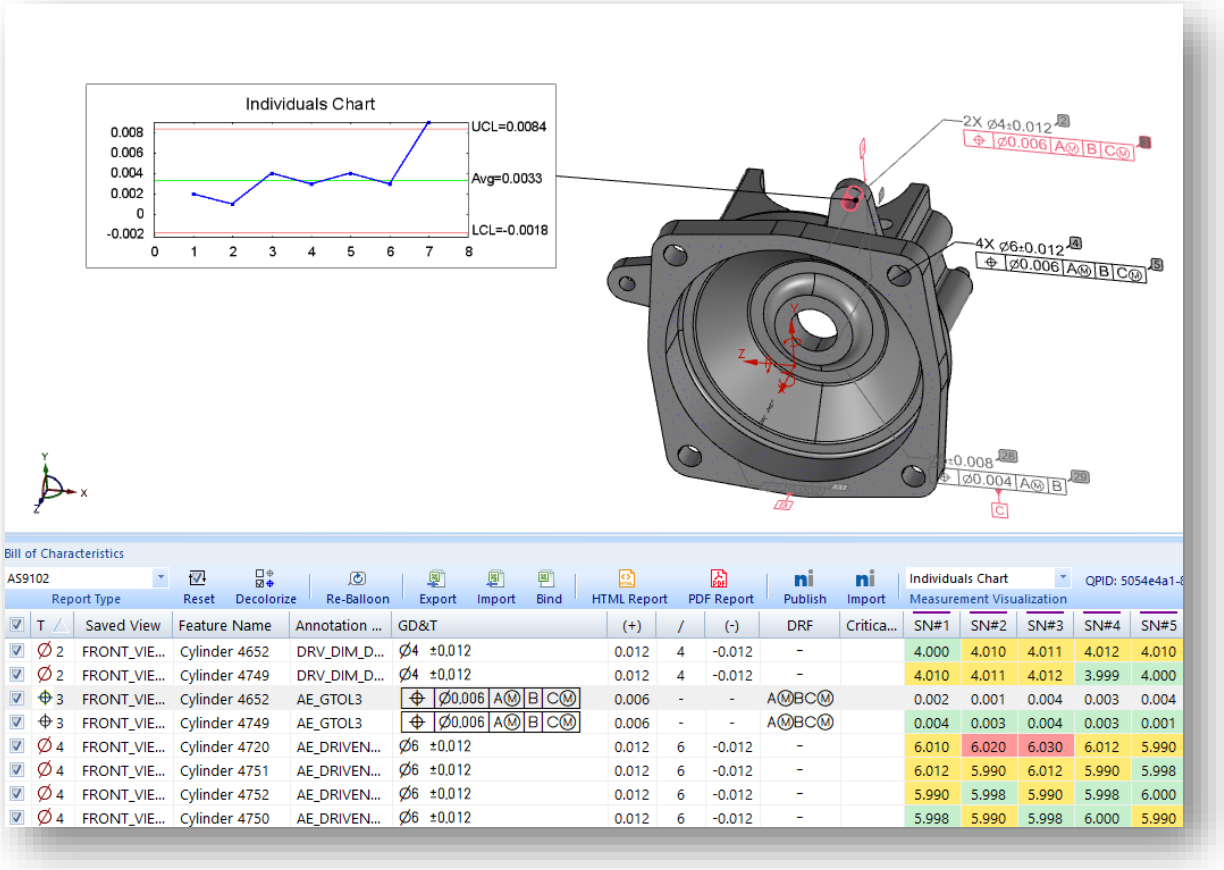
T	Saved View	Feature Name	Annotation Name	GD&T	(+)	/	(-)	DRF	Criticality
2	MBD_0	Opposite Planes 2778	ad537	85	0.001	85	-0.001	-	
3	MBD_0	Opposite Planes 2778	gp12	0.75 A B C	0.75	-	-	ABC	
4	MBD_0	Generic 2786	gp13	0.5 A	0.5	-	-	A	
5	MBD_0	Cylinder 2792	ad538	Ø25 ±0.15	0.15	25	-0.15	-	
6	MBD_0	Cylinder 2793	ad541	Ø35.2-34.8	0.2	35	-0.2	-	

Major QIF Elements
Applications: Results

Tolerances are placed on a product definition to be measured.

QIF Measurement Results is how Feature and Characteristic measurements are stored and linked to the corresponding product definition entity.

This allows for the mapping between:
Measurement ↔ Product Definition

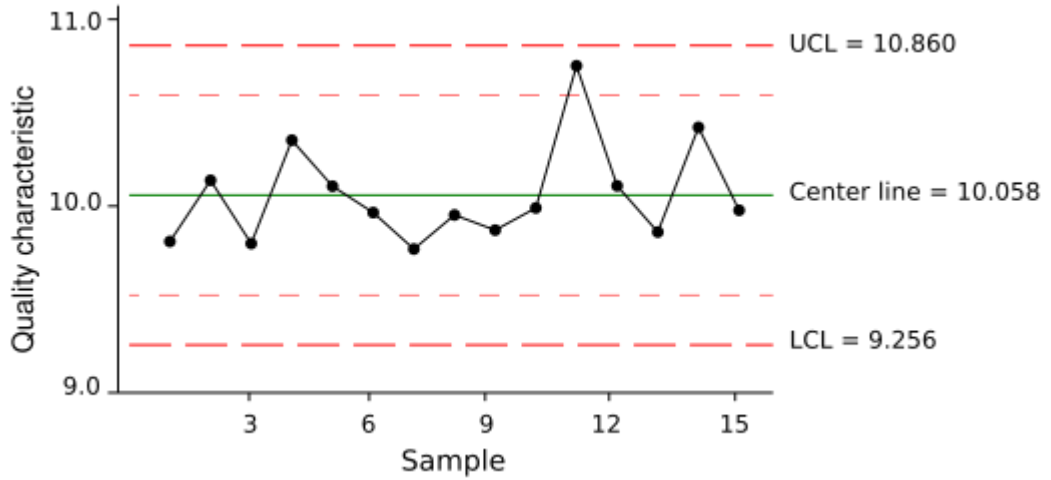


T	Saved View	Feature Name	Annotation ...	GD&T	(+)	/	(-)	DRF	Critica...	SN#1	SN#2	SN#3	SN#4	SN#5
⌀ 2	FRONT_VIE...	Cylinder 4652	DRV_DIM_D...	⌀4 ±0.012	0.012	4	-0.012	-		4.000	4.010	4.011	4.012	4.010
⌀ 2	FRONT_VIE...	Cylinder 4749	DRV_DIM_D...	⌀4 ±0.012	0.012	4	-0.012	-		4.010	4.011	4.012	3.999	4.000
⌖ 3	FRONT_VIE...	Cylinder 4652	AE_GTOL3	⌖ ⌀0.006 A Ⓜ B C Ⓜ	0.006	-	-	A Ⓜ B C Ⓜ		0.002	0.001	0.004	0.003	0.004
⌖ 3	FRONT_VIE...	Cylinder 4749	AE_GTOL3	⌖ ⌀0.006 A Ⓜ B C Ⓜ	0.006	-	-	A Ⓜ B C Ⓜ		0.004	0.003	0.004	0.003	0.001
⌀ 4	FRONT_VIE...	Cylinder 4720	AE_DRIVEN...	⌀6 ±0.012	0.012	6	-0.012	-		6.010	6.020	6.030	6.012	5.990
⌀ 4	FRONT_VIE...	Cylinder 4751	AE_DRIVEN...	⌀6 ±0.012	0.012	6	-0.012	-		6.012	5.990	6.012	5.990	5.998
⌀ 4	FRONT_VIE...	Cylinder 4752	AE_DRIVEN...	⌀6 ±0.012	0.012	6	-0.012	-		5.990	5.998	5.990	5.998	6.000
⌀ 4	FRONT_VIE...	Cylinder 4750	AE_DRIVEN...	⌀6 ±0.012	0.012	6	-0.012	-		5.998	5.990	5.998	6.000	5.990

Major QIF Elements
Applications: Statistics

QIF Statistics can be used in one of two ways:

- **Specify statistical method**: define the SPC rules that should be applied to measurement data, when it is acquired
- **Show SPC Results**: bundle up a set of results data, and show the result of the SPC analysis of that dataset

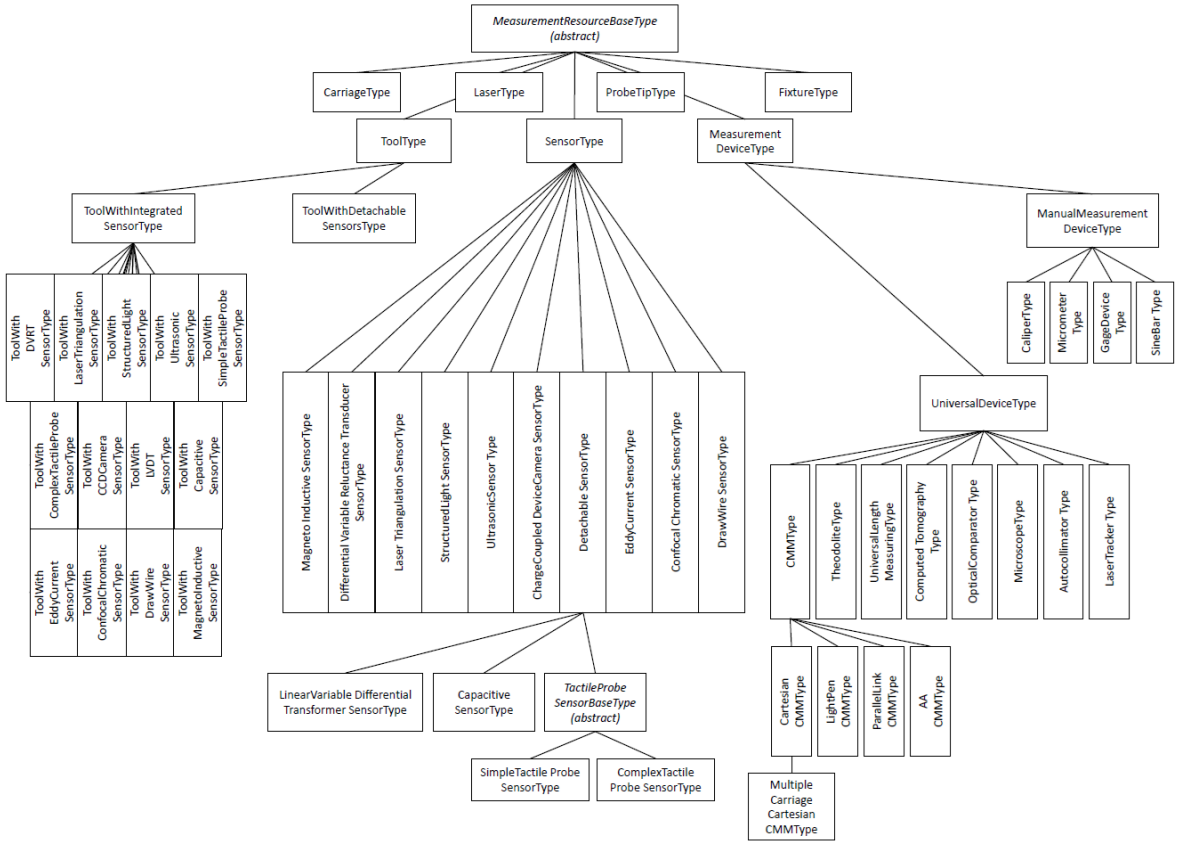


Major QIF Elements
Applications: Resources

What measurement equipment will be used to measure something?

QIF Resources is used to specify this equipment.

A huge range of devices are described in QIF 3.0, including CMMs, calipers, gages, theodolites, lots of sensors, and more!



Major QIF Elements
Applications: Rules

Provides a mechanism to specify things like:

- Measurement best practices
- Measurement templates
- Corporate standards for measurement

How does it work?

```
If ("Boolean condition") then
{
   Corresponding "action"
}
```

Boolean conditions that can be checked:

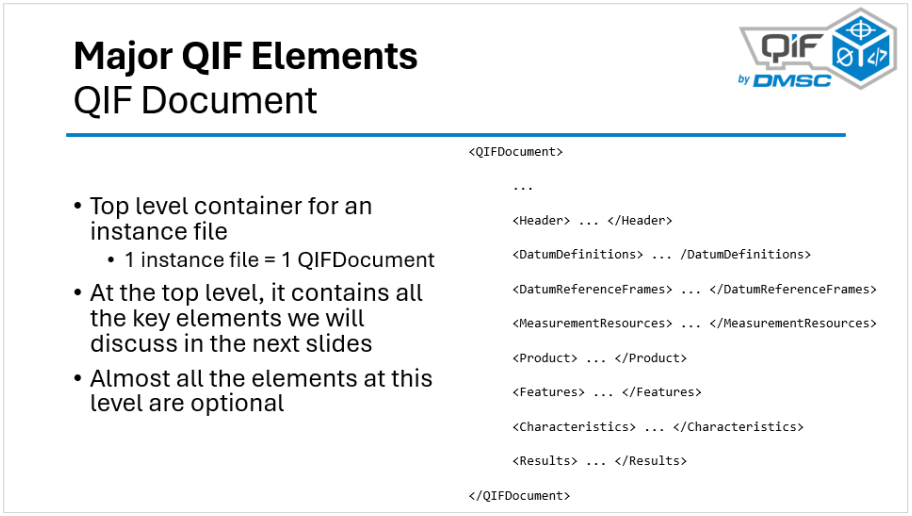
- Tolerance type, value, etc.
- Feature type, size, etc.
- Is feature a datum?
- If feature internal/external?
- User defined sampling category
- Anything else can be evaluated to a Boolean results, e.g., "surface area >= 150"

Actions that can be taken:

- Sampling point count, density, and sampling strategy
- Fitting algorithm
- Measurement equipment: required, allowed, prohibited

Modularity of QIF Data

Back to QIF Document…



A single QIF instance file is a QIF Document which might contain:

- Product (MBD)
- Plans
- Results
- Statistics
- Resources
- Rules

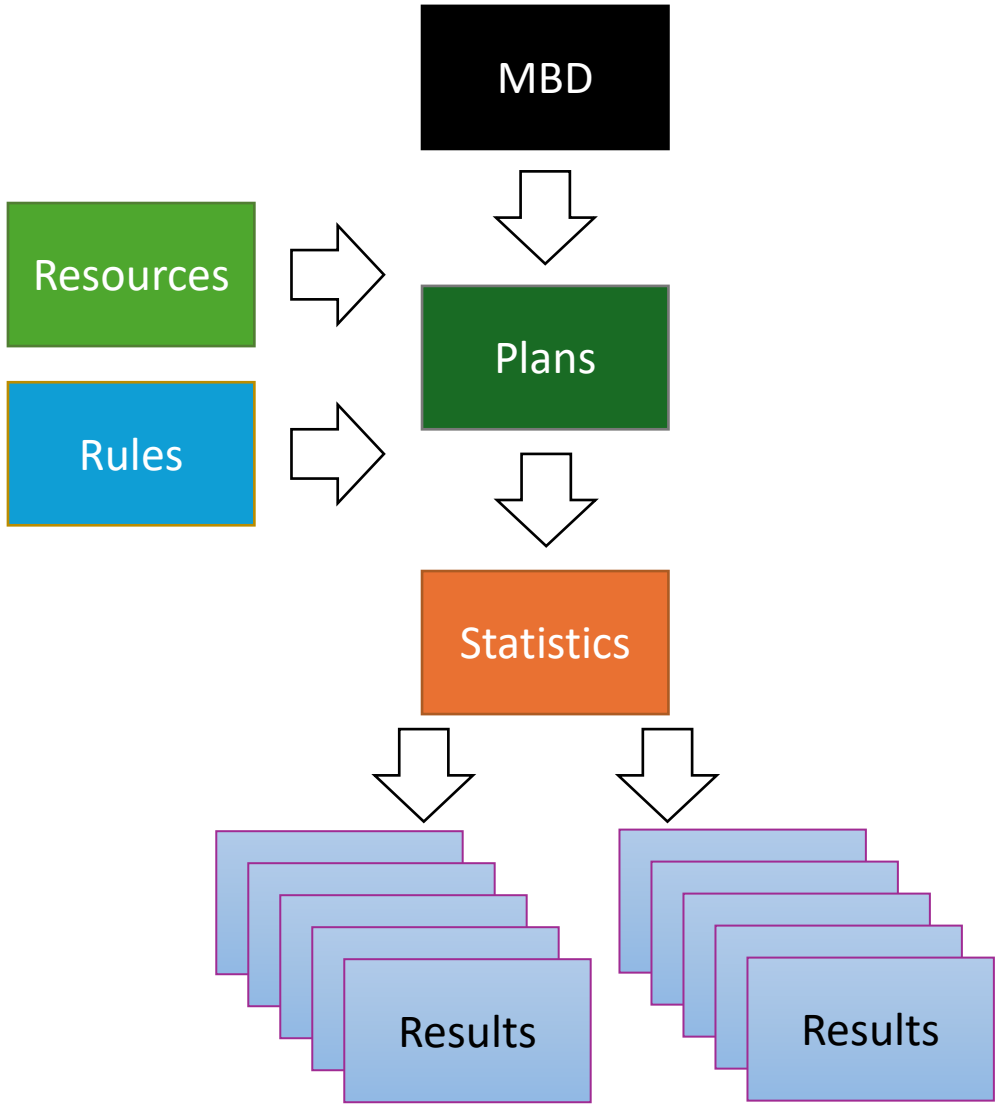
A single part made by a manufacturing enterprise will typically have 1 MBD product definition, **but may have multiple sets of plans, results, statistics**. Also, the resources or rules used on this part might be used on thousands of others.

This is why QIF is designed to support a federated data model, where a single mapped bulk of QIF data can be stored across multiple instance files.

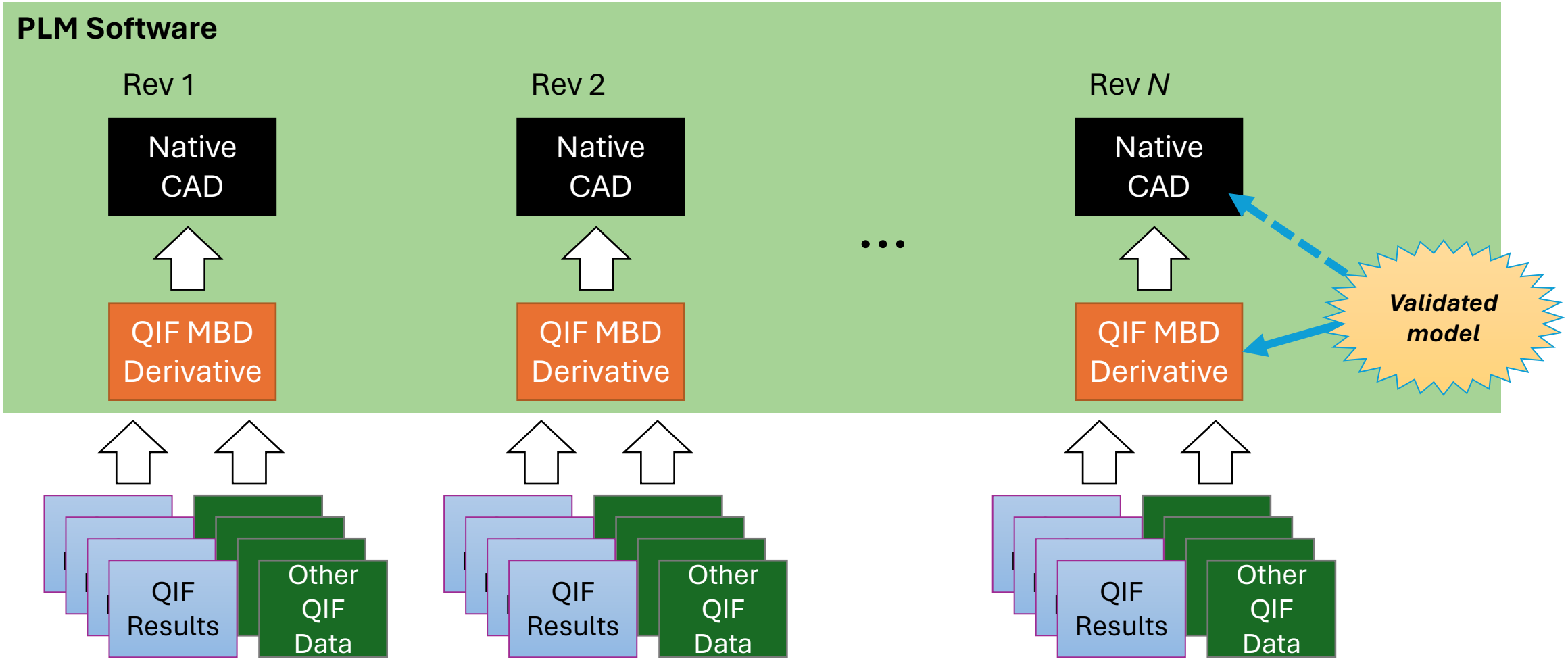
Modularity of QIF Data

QIF data can be split up among various instance files. For example, the diagram on the right shows a possible group of interrelated QIF instance files, where one box corresponds to one instance file.

But remember:
A QIF instance file usually *does* carry more than one type of data. So, it doesn't typically make sense to ask, "*is this a QIF MBD file, or a QIF Plans file?*" It might be both!



QIF at the Enterprise Data PLM Level



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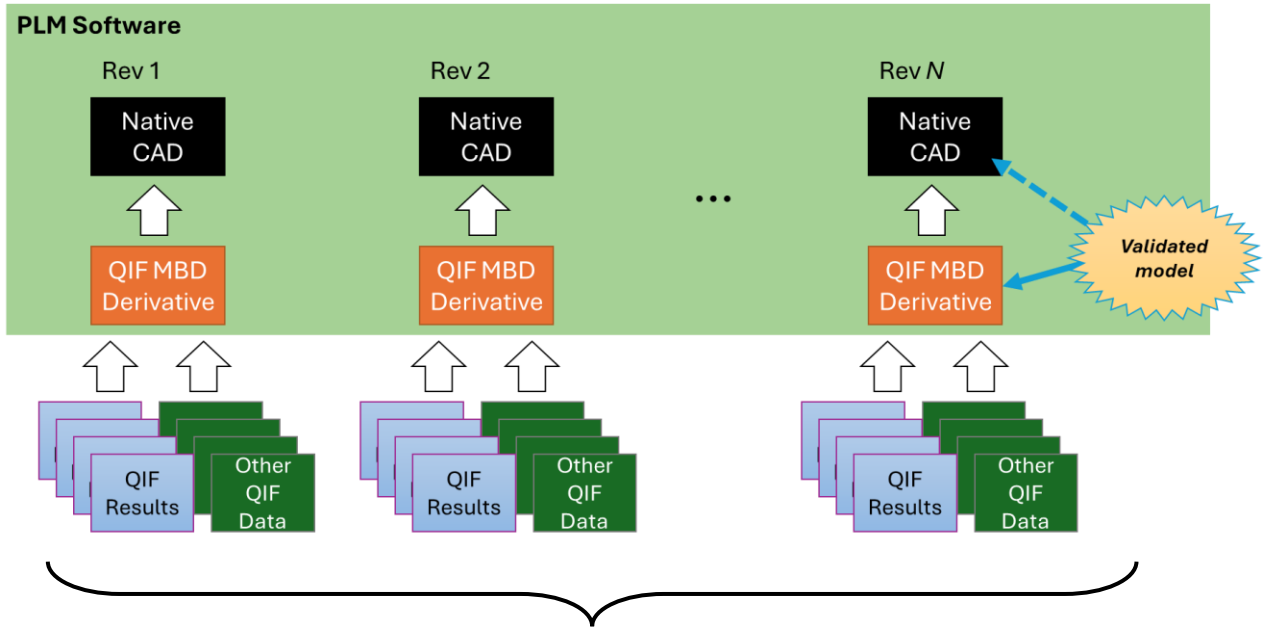

Features/Characteristics which are not changed between revisions can be easily correlated.

Mapping maintained from "**single source of truth**" (i.e., CAD model in PDM) and **all measurement data**

Very high data resolution – the measurement data for

- "POS_01" tolerance on
- Part "abc"
- With "123" serial number

corresponds to a specific annotation on our authoritative product definition for a specific physical part instance.

Remember: your metrology department gathers **more data** about your product & process than any other part of your enterprise. Are you leveraging this information?

This is Digital Twin.

Summary

Back to the basics...

The Building Blocks of QIF: **Features & Characteristics**

Model geometry is wrapped by **Features**
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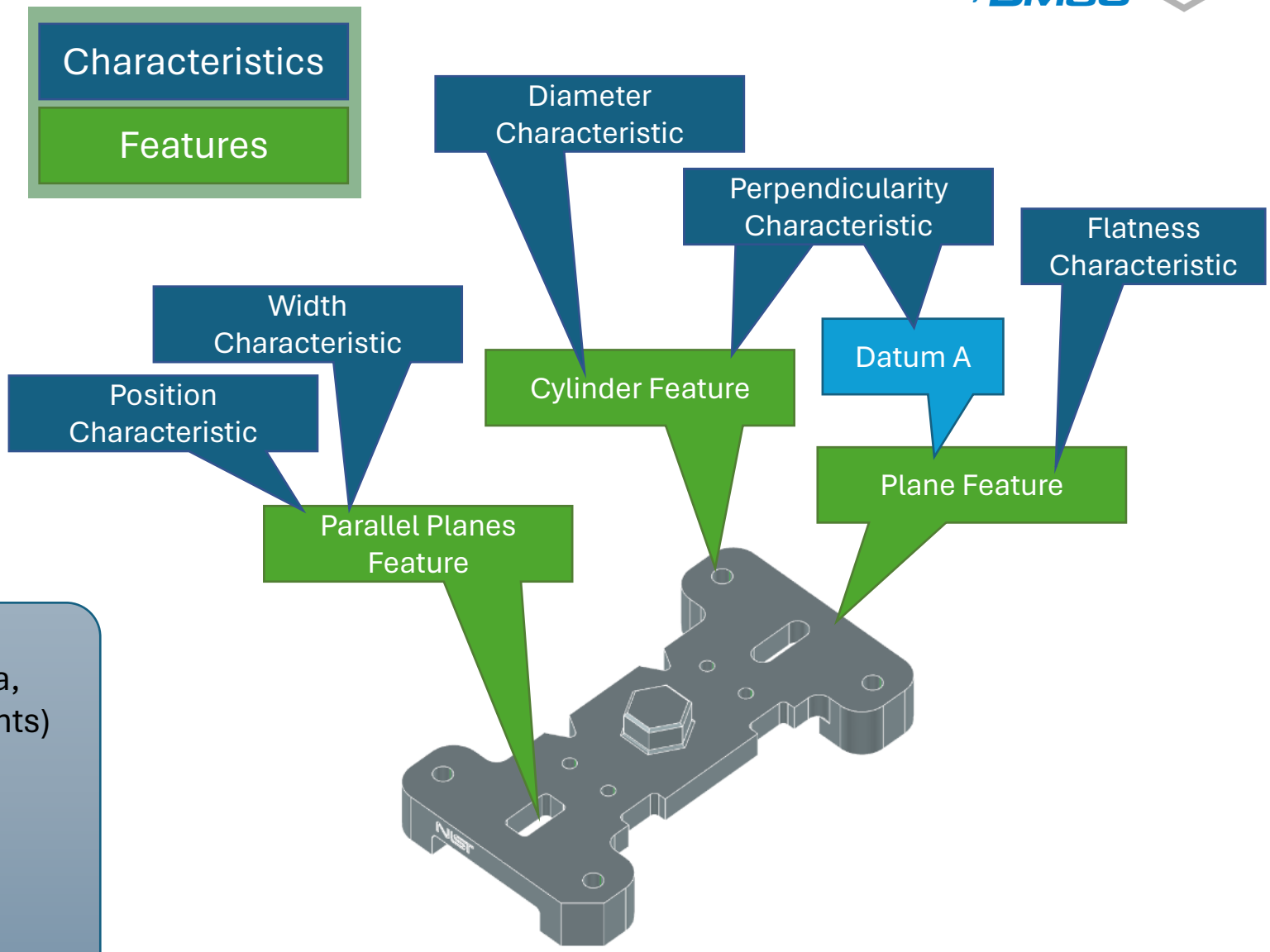

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Q&A

Thanks!!

Daniel Campbell
Chair, QIF Working Group
Member, DMSC Board of Directors
Vice President, Model-Based Definition, Capvidia

dc@capvidia.com

https://www.linkedin.com/in/daniel-campbell-051769/

Check out our online community:

https://qualityinformationframework.github.io/

Schema Browser: If you want to dig into the schemas in detail, you should check out this schema browser. It allows you to easily navigate the structure and relationships of the QIF data model.