A QIF Case Study – Maintaining the Digital Thread from OEM to Supplier

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ABSTRACT

The Quality Information Framework (QIF) standard was used to facilitate a Model-Based Definition (MBD) pilot at a Tier 1 Manufacturer. The pilot specifically addressed the 3D data interoperability gap that exists when 3D data is passed from an Original Equipment Manufacturer (OEM) to a supplier. QIF v3.0 is an American National Standard that provides a common interface for digital interoperability that maintains the digital thread (3D data traceability) and enables closed loop feedback throughout product manufacturing. For example, it captures measurement results in the product model adjacent to the design requirement (i.e., tolerance). QIF defines, constrains, and provides for the exchange of MBD, quality planning, measurement results, and enterprise connectivity via a persistent unique identification method called the QIF Persistent Identifier (QPId). QPIds are universally unique identifiers (UUIDs). The use of QIF and QPIds allows for the digital capture of the design requirements and measurement results without manual data entry. The techniques and tools used in this pilot resulted in reduced lead time, increased data reporting accuracy, and improved OEM-to-supplier collaboration.

QIF MBD Pilot Case Study

The Problem

Passing 3D model data without a drawing from an Original Equipment Manufacturer (OEM) to a supplier generally creates interoperability chaos. This chaos inhibits the opportunities available in manufacturing today. NIST estimates there are $100 Billion annual savings available to industry if we [1]:

1. Adopt open standards
2. Adopt model-based methods
3. Move to advanced manufacturing

Because the manufacturing industry relies so heavily on static documentation methods (e.g. drawings) that are not machine-readable, the industry cannot leverage the $100 Billion annual opportunity.

To date, native and derivative solutions have been employed, but lack automated data traceability. Today's methods rely on manual human analysis to compare design requirements against actual measurements (e.g. copy a table of data from Excel® into another table in another document to capture measurements).

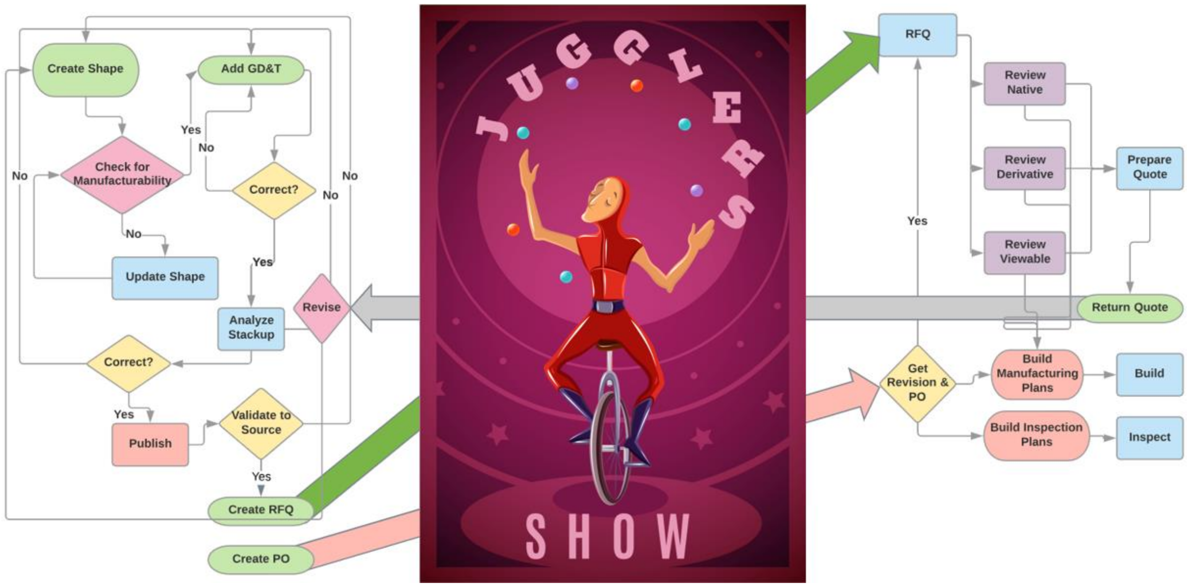

Figure 1: Today, passing data from the OEM to Supplier is a complex workflow of human checking to ensure data integrity. The reason for this is due to the 2D nature of drawing-based documentation methods. Uncertainty and suspicion in the accuracy of this static data drives some industries to spend millions of dollars each year on intensive, error-prone data exchange. [2]

Because manufacturers and especially suppliers are caught up in the way they have always done business, they are not able to see a new method. The pilot conducted at the Tier 1 Manufacturer and their Tier 2 Supplier successfully tested methods that move beyond the status quo.

The problem is not that manufacturers and suppliers do not have the tools and knowledge necessary to implement Model-Based Definition (MBD). The problem is that each of these companies has likely created their own standards and methods for how information is disseminated throughout their ecosystem. This includes both the machine-readable and human-interpretable information. While introducing a new language that offers so much potential savings by enabling advanced manufacturing capabilities, it does require a framework of standards and methods to ensure that data being transferred across the enterprise, including the supply chain, retains its authority and integrity. This also ensures that everyone in this ecosystem will be able to benefit from this new language.

Success Overview

A large OEM and high precision supplier collaborated on a pilot project of a machined part. The part was designed using Siemens NX to capture the product definition using MBD principles. The design data package was released to the supplier without releasing a 2D drawing. The supplier was able to use the native Siemens NX model as well as validated derivatives and contents of the data package to quote, engineer, and produce a part that passed First Article Inspection Report (FAIR) [3] qualification. This was done by leveraging 3D PDF and Quality Information Framework (QIF) derivative files, SOLIDWORKS, and Origin International's CheckMate plugin for SOLIDWORKS to complete design, machining, and CMM [4] programming and inspection processes. Not only were the OEM's supplier quality requirements met, the supplier also realized some very real qualitative and quantitative benefits in their engineering and manufacturing processes.

Together, by standardizing how the product definition model-based design data was characterized and transferred between the two parties, they achieved the goal of capturing the data needed at the OEM and maintaining that data in a 3D data format throughout the entire procurement cycle. Furthermore, the product characteristic data maintained digital traceability every time data was shared between the two companies.

At the core of what National Institute of Standards and Technology (NIST) is asking for (adoption of open standards, model-based methods, and advanced manufacturing) [1] is that the source native CAD model must:

1. Capture data
2. Interoperate amongst the internal enterprise

3. Be published in a traceable way to external contributors

Our conclusion is that MBD is the foundation of the enterprise that can leverage advanced manufacturing.

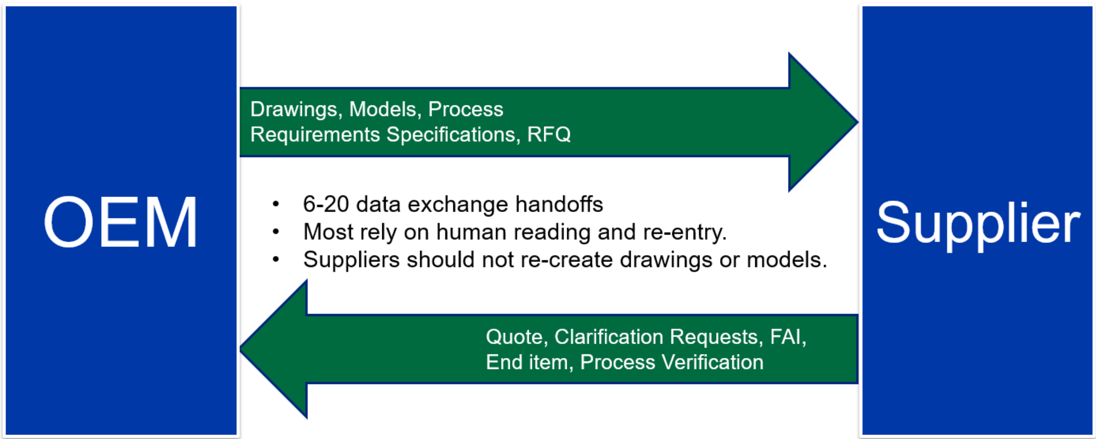

Figure 2: During the assessment and requirements phase of the pilot project, 6 to 20 manual data exchange handoffs were identified from OEM to Supplier. This is a significant amount of manual data handoffs. The pilot proved a reduction of these handoffs.

Solution Overview

Passed data that maintain machine-readable traceability from the OEM in an NX model through QIF, through manufacturing and populated the as-measured data and compared both human-readable (table text format and 3D viewable) and machine-readable. By identifying model-based characteristics defined using associated 3D annotations (annotations associated to 3D CAD geometry) in the authoritative native product definition model, the characteristic definitions remained consistent throughout the manufacturing and quality processes. These definitions were comprised of 3D CAD geometry, metadata, annotations for machine readability as well as human consumption and presentation states for human interpretation.

QIF [5] was used to maintain traceable data from OEM to supplier.

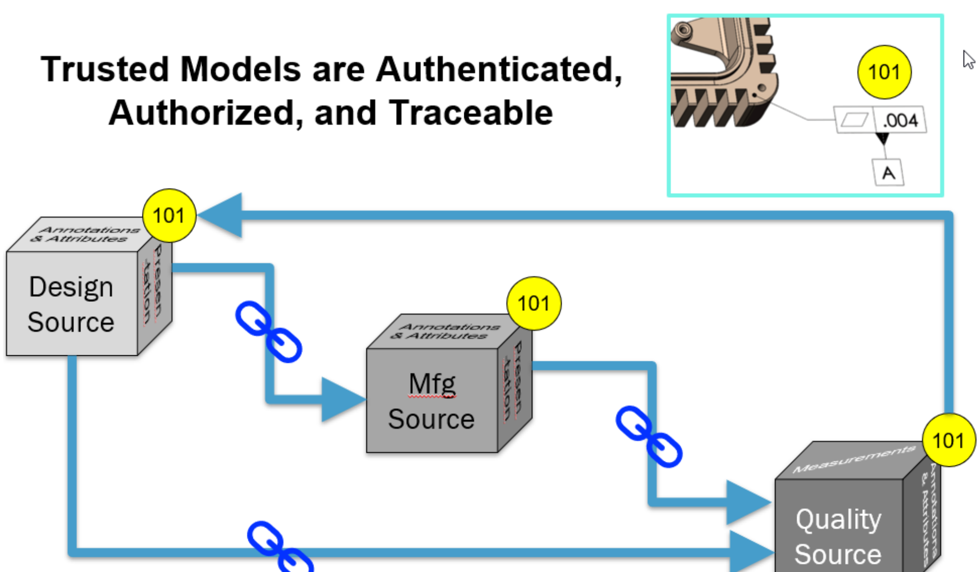

Figure 3: This pilot showed that data can pass from the Native NX Design Source to the SOLIDWORKS Manufacturing Source and record measurement results that can be viewed in 3D space (Quality Source). The 101 balloon is the unique identification that persists through all file formats.

By standardizing the language of MBD within the context of Quality Characteristics, both the OEM and the supplier were able to define and disseminate product definition information and data consistently but still allowing both parties to leverage their own tools and processes that are tailored to their own needs. For instance, the OEM used Siemen's NX as their CAD system and the supplier used SOLIDWORKS. The QIF format was able to capture both the geometry and associated annotations that could be consumed by the supplier and leveraged by their tools and processes. While this enabled some significant opportunities to automate some manufacturing and quality processes at the supplier by avoiding re-modeling and re-design efforts as well as leveraging the machine-readable elements of the product definition, it did introduce some risk that resulted in additional derivative data spawning from the model that could be corrupted and/or lose integrity during the data exchange. While there were some tools leveraged to validate the 3D geometry when creating and consuming the QIF derivative, there was a need to validate the characteristic definitions which were comprised of 3D annotations and their associated geometry.

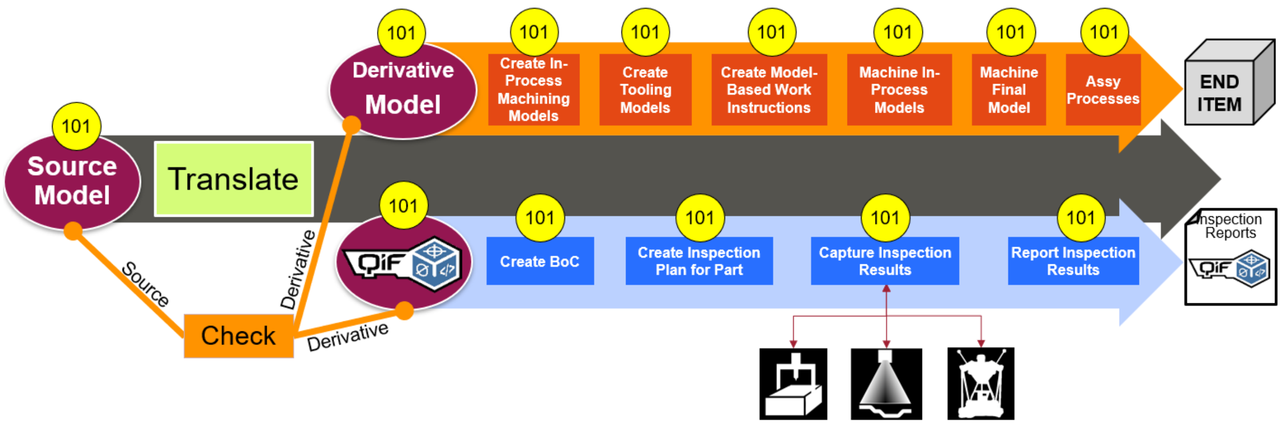

Figure 4: Validation of 3D data sets is crucial to building trust in 3D models.

The QIF derivative was successfully validated against the native Siemen's NX file using Capvidia's CompareVidia software prior to releasing the data package to the supplier. This ensured that all data sent to the supplier was trusted and validated.

Data Element		Validation Tools / Methods
Geometry	✓	CompareVidia
Annotations	✓	CompareVidia
3D IDs	✓	CompareVidia
Tolerances	✓	CompareVidia
Notes	✓	CompareVidia
Attributes	✓	CompareVidia
Presentation States (Model Views / 3D Views)	✓	CompareVidia

Figure 5: Siemen's NX / QIF derivative validation results

In addition to the OEM validating the QIF derivative, the supplier derived SOLIDWORKS data was also validated against the OEM's native NX file to further build confidence in the ability to maintain the data integrity while establishing the desired digital thread. While the geometry and metadata/attributes were able to be validated using any of the several validation tools evaluated (CADIQ, CompareVidia and Elysium), the 3D annotations had to be validated manually by opening both the NX design authority and the SOLIDWORKS derivative. Since the 3D annotations were not imported as native SOLIDWORKS DimXpert annotations but rather as FormatWorks annotations, to validate them they were manually/visually compared to ensure the text and display were equivalent and to ensure that geometry associations were retained.

PLM Software SIEMENS NX → SOLIDWORKS

Data Element	Validation Tools / Methods
Geometry ✓	Validation Tools
Annotations (Require FormatWorks) ⚠	Manual Check
3D IDs ✓	Manual Check
Tolerances ✓	Manual Check
Notes ✓	Manual Check
Attributes ✓	Validation Tools
Presentation States (Model Views / 3D Views) ✓	Manual Check

Figure 6: Siemen's NX / SOLIDWORKS derivative validation results

By leveraging the validated MBD derivatives the supplier was able to re-use the data with confidence thereby eliminating the need to re-create the product definition data in their own environment. Once the data was available in their CAD environment, SOLIDWORKS, including the MBD information they were able to build upon the product definition to create several SOLIDWORKS configurations to digitally represent the part as it would exist after each manufacturing operation. Using SOLIDWORKS MBD the supplier was even able to create their own semantic annotations that could be used to streamline the CMM programming process for In-Process inspection in addition to final inspection.

Finally, using Origin's CheckMate plugin for SOLIDWORKS, all of the MBD annotations, whether part of the original OEM product definition or the supplier's manufacturing operation definitions, were able to be used to automate much of the CMM programming and inspection reporting tasks. The QIF QPIDs were maintained at every step of the manufacturing and quality inspection processes. The results obtained by running the CMM programs were also sent back to CheckMate enabling further analysis within the context of the model if necessary, to reconcile any characteristics that failed inspection. Using CheckMate and the QIF format again, the FAIR results were automatically sent to Net-Inspect thereby satisfying the OEM's quality requirements.

"This pilot allowed us to quote the part by utilizing the 3D PDF files, manufacture complete per the NX MBD with PMI part file, and inspect the part on the CMM by utilizing a derivative from the QIF file." Lionel Andujar, Spartan Aerospace

The following resource drain and gaps were filled with the MBD methods employed in this pilot.

Resource Drain: Drawings are often not clear enough for suppliers to generate accurate quotes, so they re-create the 3D model [6].
Benefits Realized: Utilizing the 3D PDF files in the quoting process.

- Gives the supplier a complete 360-degree view of the part, removing ambiguity from the quoting process.
- Associated annotations and general notes provide the supplier with the related specifications.
- Clearly defines features and associated tolerances.
- No longer need the native CAD as a resource for proper quoting.

Resource Drain: Forty percent of respondents in a Lifecycle Insights study state that suppliers or downstream consumers re-create the 3D model. Many tool designers re-create the design model because the drawing is often not enough to develop a model for tooling, especially for designs with complex geometry [6].
Benefits Realized: Utilizing the MBD/PMI native and translated CAD files.

- Suppliers can use the CAD file to produce the manufacturing processing part models.
- Create internal 3D PDF operation sheets which eliminates manufacturing process ambiguity.
- Now have the potential to use PMI to minimize machine programming time.

Resource Drain: 60% of Quality planning time is spent on manual data entry [7]
Benefits Realized: CMM programming automation needs to improve considerably. Nonetheless, we were able to partially program the CMM by utilizing a derivative from the QIF file.

- Partially automated creation of inspection plan utilizing the PMI from the QIF file.
- The supplier experienced a 30% CMM programming time savings.
- There is potential to achieve a 70% CMM programming reduction.

Gaps Identified

SOLIDWORKS human viewability of the data – No DimXpert API access for QIF developers.
Complete automation through CMM.

Conclusion

Defining a product utilizing MBD principles and utilizing the QIF standard for transferring product definition data between OEMs and suppliers enables an OEM to adopt MBD principles in their product definitions as well as the supplier to manufacture a product to the OEM's quality requirements. Successful handoff of machine and human readable data from OEM, NX to Supplier, SOLIDWORKS and back into the OEM enterprise-level inspection database Net-Inspect. Industry has estimated cumulative enterprise labor savings in the 20% to 40% range. This pilot validates the supposition of these savings across the OEM to supplier handoff.

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