CADValidator: A Critical Aid for the Model-Based Enterprise

Abstract
Learn the importance of validation for deployment of model-based engineering practices. In addition, understand what functionality is critical in a validation solution and report for both engineering change and translation scenarios.

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Makers of automobiles and aerospace vehicles and the US Department of Defense are eager to employ what they call “Model-Based Definition” (MBD). MBD refers to a 3D model\(^1\) that includes associative product and manufacturing information (PMI), that defines the product in a manner that can be used effectively without a drawing graphic sheet (Action Engineering). To successfully supersede drawings, models must contain information such as geometric dimensions and tolerances (GD&T), notes, finish symbols, material specifications, and other non-graphic attributes that traditionally appear on manufacturing drawings.

ANSI standard ASME Y14.41, *Digital Product Definition Data Practices*, specifies how 3D annotations and attributes, frequently referred to as PMI (Product Manufacturing Information), are applied to models. It calls for annotations to be organized on invisible annotation planes. As defined by ASME Y14.41, annotations are always displayed with the model. Attributes are “hidden” information embedded in the model. The most common attribute data element is metadata. Upcoming ASME standards will define how annotations are grouped along with saved views (a capture of zoom and orientation) for increased clarification of the 3D model readability. When these grouped annotations and saved views are selected, only those notes and symbols attached to it become visible.

\(1\) Definition of model as defined in ASME Y14.41-2012
When CAD vendors first implemented 3D annotations, they were simply graphic images attached to the CAD model. But manufacturers also wanted annotations that were digitally associated to the geometric features they represent, as to be read directly into manufacturing software. This process eliminates the need for humans to read information from models and enter it into other systems, activities that take time, cost money, and may introduce errors in translation. Machine- or software-readable PMI is often called “semantic PMI,” or digitally associated annotations.

When dimensions and tolerances appear only on drawings, successive versions of drawings were left to manual interpretation. But with 3D annotations, more sophisticated tools are needed and able to compare models with higher efficiency and quality.
Revision management

One of the challenges many manufacturing companies face today is the management of engineering changes and model revisions. In a drawing-based organization, engineering changes are mostly documented within drawings with no graphical validation or representation of the change. A report that summarizes what “Is” versus what “Was” is described in text, while zone information of the change location is noted for reference to the 2D view. This process is usually manual, time consuming and relies on the change notice documentor to ensure information is complete. However, the consumer is also restricted to interpret what was documented with limited space in both text and the 2D view. Organizations can suffer major loss of efficiency by manually reviewing and recording these changes. Furthermore, unintentionally sending defective data for manufacturing is an extremely costly consequence. Figure 2 demonstrates a typical Engineering Change Notice form, whereas interpretation can be ambiguous, connecting location of change within the drawing can be time consuming, and the change may never get updated in the 3D model.
With digital PMI associated to the 3D model that is both machine-readable and human-interpretable, a model-based definition approach provides opportunity for organizations to be far more effective and efficient with revision management.

**Difference-detecting software and optimal reporting**

Elysium, Inc., an industry leader in CAD translation and data quality software, has introduced a new tool for comparing 3D CAD models with semantic PMI. Elysium’s CADValidator can detect variance between two models and report the information graphically in 3D with a listing of all changes. Reports are available in both HTML and 3DPDF formats. Users of the report require no special viewing software—only a web browser or Adobe Acrobat. Using the reports, CAD operators
can find and correct defects quickly before releasing the source data for manufacturing, among many other use cases. A report that is easily opened, accessible, and understood by its consumers is critical to the success of deploying Model-Based Definition. In addition to the user reports, results are automatically generated in a structured XML format, which can be parsed by any downstream process.

Figure 3 – Elysium’s 3D PDF validation report detecting an engineering change in which a hole diameter has been modified from 40 mm to 52 mm. Associative geometry highlights for easy interpretation.
Translation errors

Once model-based practices are deployed within an organization, derivatives may need to be created for effective data exchange and visualization. By extending the Model-Based Definition into these derivatives and allowing downstream or upstream processes to consume the data, an organization is now tapping into a Model-Based Enterprise (MBE). Although achieving MBE throughout the entire product lifecycle is an extreme challenge, benefits can be realized using digital information at a highly connected level.

Most people are aware that when models are translated from one CAD system brand to another, errors can occur. Errors also can occur when translating to or from proprietary CAD formats to industry standards such as ISO 10303 (STEP) and the Initial Graphic Exchange Specification (IGES). Part faces, data and annotation planes can shift position. Characters in notes and geometric annotations can change values. Geometric entities and symbols may fail to appear in the target system. Such errors occur due to the difference in mathematical kernels behind the geometry and PMI definition. They also occur due to the level of interpretation when it comes to importing or exporting standard or neutral formats. Different topological rules, tolerances, and even poor design practices may contribute to translation issues as well.
What is less well known is that translation errors can occur within the same CAD system. Models created correctly in a prior software release may contain errors when opened in later releases. API changes can be one factor in such instances. Errors also may occur when models are translated from CAD systems, such as Siemens NX or Dassault Systèmes CATIA, to compact “visualisation formats,” such as Siemens JT or 3D PDF. Such errors may be hard for human eyes to detect. However, they can introduce significant defects in precision machinery. Whether using a drawing-based documentation system or a model-based one, it is always critical to have configuration management. Because model-based data is purely digital, the quality and configuration management checking can be 100% accurate, and never left to human interpretation.

Elysium’s CADValidator can assure that models translated from other systems or from previous releases of the same system are identical. It also validates CAD data for short- and long-term storage and retrieval to ensure any derivatives do not compromise quality. CADValidator assures that
derivative models with long production lives remain faithful to their originals, which is critical when the originating CAD system may have gone through many releases or is no longer available. It is well-suited for companies that deploy LOTAR (Long Term Archiving and Retrieval) practices that rely on industry standard formats such as STEP or ISO 14739, the international standard version of 3D PDF.

Figure 5 - Example of an Elysium HTML validation report comparing two CATIA models from different versions. The graphics area and Element List confirm that the GD&T are identical from version to version.
CADValidator compares the following element types:

- System Attributes (metadata)
- Notes
- Datums
- Datum Targets
- GD&T per ASME Y14.5 and Y14.41
- Dimensions
- Saved Views
- Attributes of Faces
- Attributes of Isolated Curves

2 Definition of saved view as defined in ASME Y14.41-2012
CADValidator also checks for the following geometry difference types:

- Face Geometry
- Isolated Curve Geometry
- Free Edge Geometry
- Isolated Points

The Elysium software detects errors in annotation values, such as “C” instead of “G” or “+0.05” instead of “+0.005.” It also detects changes in position of both annotations (such as datum targets and tolerance blocks) and geometric entities (such as curves and faces). Figure 7 illustrates an example of detecting a moved position of an annotation. Customers are able to set filters within CADValidator to ignore positional errors of no significance. For instance, if the customer doesn’t care if notes shift by 0.1 inches or less, the filter can exclude such errors from the list of differences.
Figure 7 – Here, Elysium’s 3D PDF is reporting a detected variance in a GD&T element’s location between two similar CATIA models. These types of variances may be easily filtered out from the report should the interested party not care to identify them as significant.

Detecting geometry translation changes is a crucial step within a Model-Based Enterprise. When derivative models, such as STEP, are generated from the original source model, likely a native proprietary model file format, identifying geometry variances validate accurate translation. Figure 8 depicts how geometry variances are identified.
Figure 8 – In this 3D PDF report, Elysium’s comparison technology has identified a face to face variance between two similar NX parts. The Max Deviation Value and Coordinate are listed so that the user can quickly locate the variance and magnitude of variance in the model. The color map helps the user understand where the face has changed, the amount and the direction of the detected variance.

Elysium enhances software according to market demand. If a customer contributes requirements to additional capabilities, the functionality is then part of Elysium’s general product offering for use by all clientele.
Conclusion

Model-Based Definition enables the automation of 3D capture and comparison capabilities. A highly robust validation software such as CADValidator enables downstream processes to leverage MBD data. While automating form fit function changes, CADValidator also captures presentation and representation changes that are not otherwise captured in a drawing-centric processes.

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Action Engineering helps organizations small and large achieve their Model-Based Enterprise (MBE) goals by motivating stakeholders, delivering training, and providing business planning and MBE/MBD implementation consulting services.