

# Apply Visualization Tools To Achieve Quality... Affordably

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Quality itself is no longer a differentiator among manufacturers. Today, the focus of manufacturing quality has shifted to a discussion of “affordable” quality. The question asked by manufacturers is not how to achieve quality, but how to achieve it within cost and time constraints.

Successful manufacturers achieve affordable quality by using simulation-based dimensional engineering (DE) and tolerance analysis processes to address quality problems before they occur.

Many products are subjected to 3D-model-based tolerance analysis as a part of a DE process. Such analyses help engineers understand dimensional fit characteristics and quality status at all stages of design and production. This is not new or revolutionary. However, a “closed-loop” DE process, which relies on visualization tools and techniques, enables engineers to define and refine objectives across the product lifecycle so they can achieve affordable quality.

A 3D-model-based closed-loop DE process includes several steps:

1. **Establish Build Objectives:** A team analyzes the quality levels of competitor products to determine appropriate levels of variation allowable. The balance between build requirements and cost will vary based on planned quality levels.
2. **Set Build Strategies:** A build strategy defines the way parts will be located and held within an assembly. There is always more than one way to manufacture and assemble a product; the goal is to find the best approach given quality and cost objectives.
3. **Establish GD&T Requirements:** Geometric dimensioning & tolerancing (GD&T) is applied to parts and subassemblies driven by the build objectives and strategies. Datum locators are set, and related dimensions are measured based on their deviation from nominal.
4. **Analyze Tolerances:** The “assemblability” of a part is ensured before production. In pre-production, possible product and process changes are optimized before expensive tooling changes are made during production. Tolerance analysis produces neutral facts for decision-makers.
5. **Establish Measurement Plans:** A measurement plan includes the critical

quality characteristics that have been identified through tolerance analysis, noting limits for each part, subassembly, and final assembly. The plan is a roadmap of which critical features to monitor through 3D-based analysis during production.

6. **Generate Dimensional Data Reports:** As a product enters pre-production and initial runs begin, quality inspection data are collected and reports generated to ensure measurement plans are followed and end-products achieve quality expectations.
7. **Conduct Root Cause Analyses:** As is the case at most other stages, if end-products are not achieving the tolerances expected, engineers can “loop back” to see where problems originated and either resolve issues or adjust build objectives, strategies, or tolerances.

Technology tools allow manufacturers to appraise design, fabrication and assembly robustness by evaluating GD&T, tooling and build sequencing – all before production. They produce 3D-model-based tolerance simulations that identify areas of concern, potential failure rates, and statistical results, such as percent out of specification, for each measurement. Sensitivity analyses review each tolerance as it relates to each measurement and identify its percentage contribution or affect on each measurement.

Together, a closed-loop DE process and 3D-model-based tolerance analyses enable affordable quality by minimizing the following costs:

- **Prevention Costs** (Costs of preparing and implementing a quality plan): A closed-loop DE process includes the development of quality plans for each product using tools and processes that are well-established, speedy and efficient.
- **Appraisal Costs** (Costs of testing, evaluating, and inspecting quality): Testing, evaluation and inspection of quality are included as critical components of a closed-loop DE process – again, through an effective, resource-efficient process.
- **Internal Failure Costs** (Costs of scrap, rework, and material losses): With the capability for users to “loop back” and make adjustments during the “as-built” phase of a product’s lifecycle, the closed-loop DE approach minimizes internal costs associated with scrap and rework.
- **External Failure Costs** (Costs of failure at customer site): The use of a closed-loop DE process, with its checks and balances, minimizes the number of quality defects – minimizing returns, repairs and recalls.

In short, a closed-loop DE process with tolerance simulation tools and techniques

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enables engineers to optimize the balance between time, cost and quality so they can achieve quality – affordably.

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