

## **Geometric specification & verification – Symbiosis in tolerancing and metrology**

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**Tutorial Abstract:** This tutorial will provide attendees with a comprehensive introduction to the language of geometric product specification (GD&T), combined with the practical considerations of determining conformity or nonconformity to these specifications (metrology). While geometric specifications are well defined on ideal geometry, the interaction of non-ideal geometry with various measuring systems provides challenges in determining conformity to the specifications. This tutorial uses the discussion of gaging and measuring techniques to not only reinforce the understanding of the geometric specification, but to provide the attendee with guidance in choosing and utilizing measuring systems. The two-part tutorial will build from basic concepts of specification and gaging to more advanced topics such as functional tolerancing, coordinate metrology algorithms, sources of measurement error in metrology systems, and common areas of misalignment or ‘methods divergence’ between the intent of a specification and the method of verification. While there will be some interplay between the two parts of this tutorial, Part 1 will largely focus on specification (GD&T) while Part 2 will largely focus on verification (metrology).

*Note: Part 1 of this tutorial is strongly recommended as a prerequisite for Part 2, which will use vocabulary, symbology, and concepts from Part 1 extensively. Part 1 may be taken alone if desired.*

**Dr. Jaime Berez** is an Assistant Professor in the Department of Mechanical Engineering and Engineering Science at UNC Charlotte where he works with the Center for Precision Metrology, an industry-university collaborative research center. He conducts research at the intersection of advanced manufacturing and metrology, often with a focus on metrology as applied to metal additive manufacturing (AM) machines and workpieces. His research often leverages geometric dimensioning and tolerancing (GD&T) and he is passionate about integrating engineering product definition concepts (GD&T, metrology, standards) into engineering curricula using strong teaching pedagogy. Jaime is certified by ASME as a Senior Level GD&T Professional (GDTP) in accordance with the qualifications of ASME Y14.5.2–2017.

**Dr. Edward Morse** is the Norvin Kennedy Dickerson Jr. Distinguished Professor in mechanical engineering at the University of North Carolina at Charlotte, and is the director of UNC Charlotte's Center for Precision Metrology. His current research interests include large scale metrology, assembly modeling and analysis, machine tool metrology, uncertainty estimation and analysis, tolerance standards and modeling, and various aspects of computational metrology (including the application of machine learning). Ed is the chair of the ASME B89 committee on Dimensional Metrology and is a long-time member of ASME Y14.5.1 on the Mathematical Definition of Dimensioning and Tolerancing Principles. He also represents the US on ISO Technical Committee 213 in working groups dedicated to metrology, tolerancing, and uncertainty.