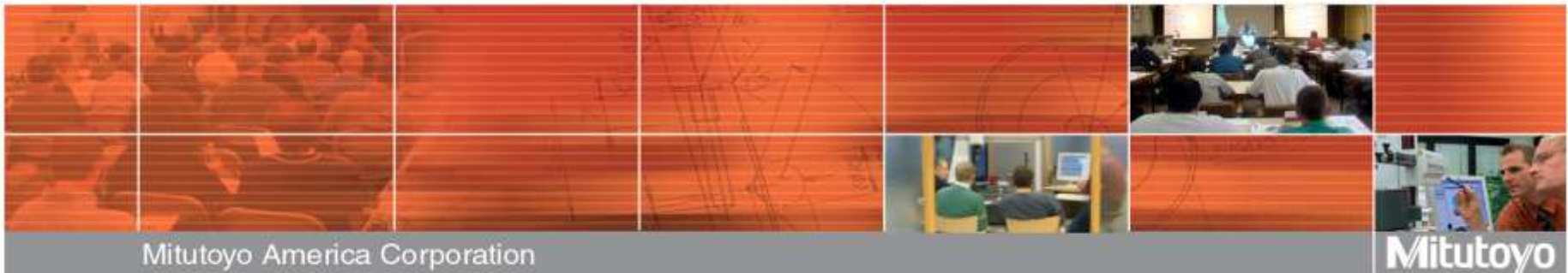


# The International Standard for Specifying and Testing CMMs with Imaging Probing Systems

Dr. Jim Salsbury, Corporate Metrologist

# New ISO 10360-7:2011

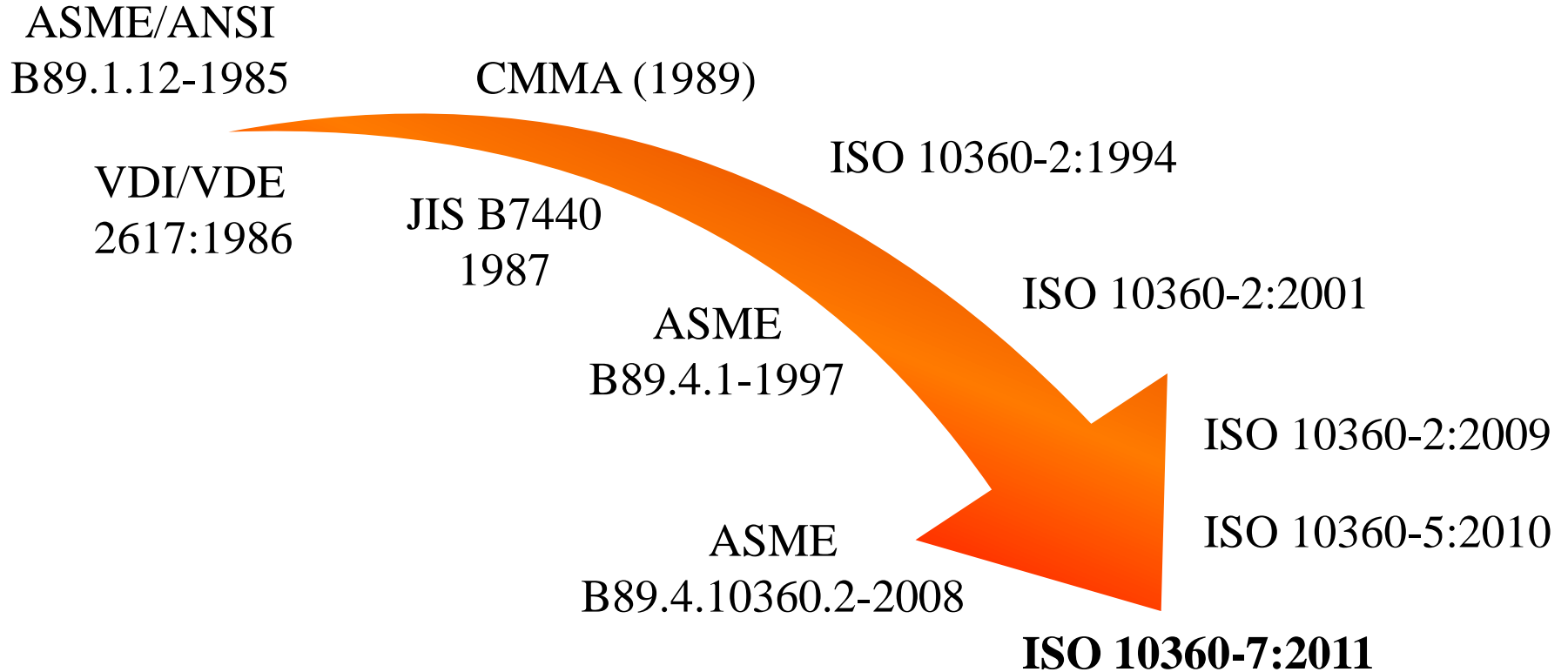
- Full title of new international standard:
  - ISO 10360-7:2011, Geometrical product specifications (GPS) – Acceptance and reverification tests for coordinate measuring machines (CMM) – Part 7: CMMs equipped with imaging probing systems.
- Developed by the international standards organization (ISO):
  - Technical committee 213, working group 10 on CMMs
  - Task force leader: Jim Salsbury, Mitutoyo America
  - Publication date: June 1, 2011



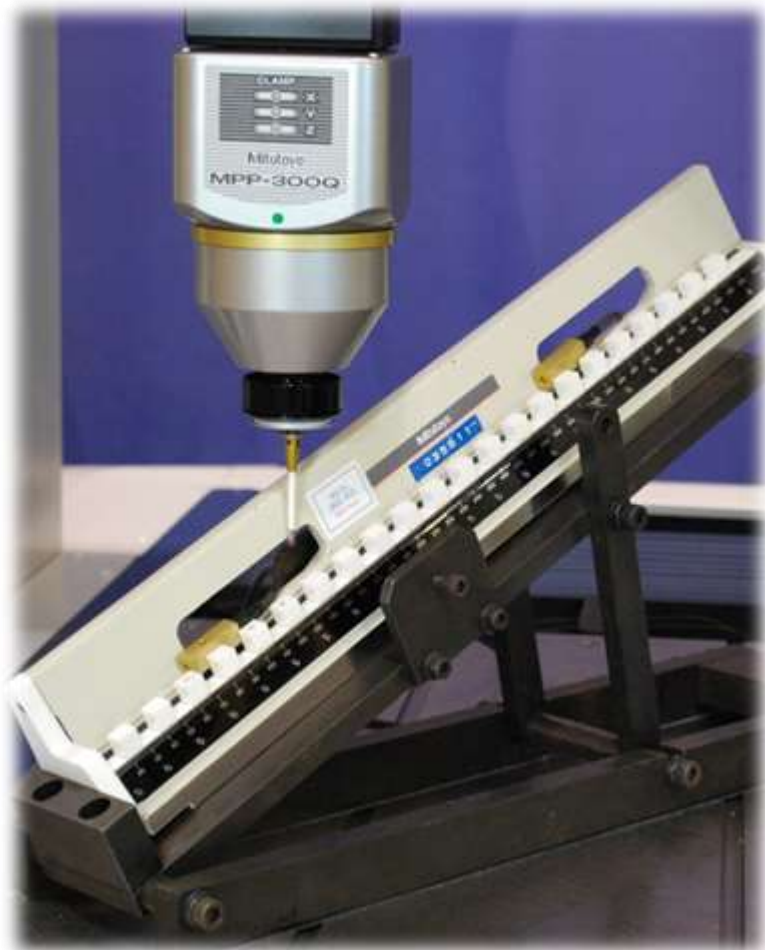
# Summary of ISO 10360 CMM Standards

- ISO 10360-1:2000 Terminology.
- ISO 10360-2:2009 Length tests, E (contact probing systems).
- ISO 10360-3:2000 Rotary table tests.
- ISO 10360-4:2000 Contact scanning tests.
- ISO 10360-5:2010 Contact probing tests, P.
- ISO 10360-6:2001 Software testing.
- ISO 10360-7:2011 CMMs with imaging probing systems.
- ISO/DIS 10360-8 Optical distance probes (in development).
- ISO/DIS 10360-9 Multi-sensor CMMs (in development).
- Others in development – laser trackers, CT, articulating arms, etc.

# Evolution of CMM Performance Testing Standards



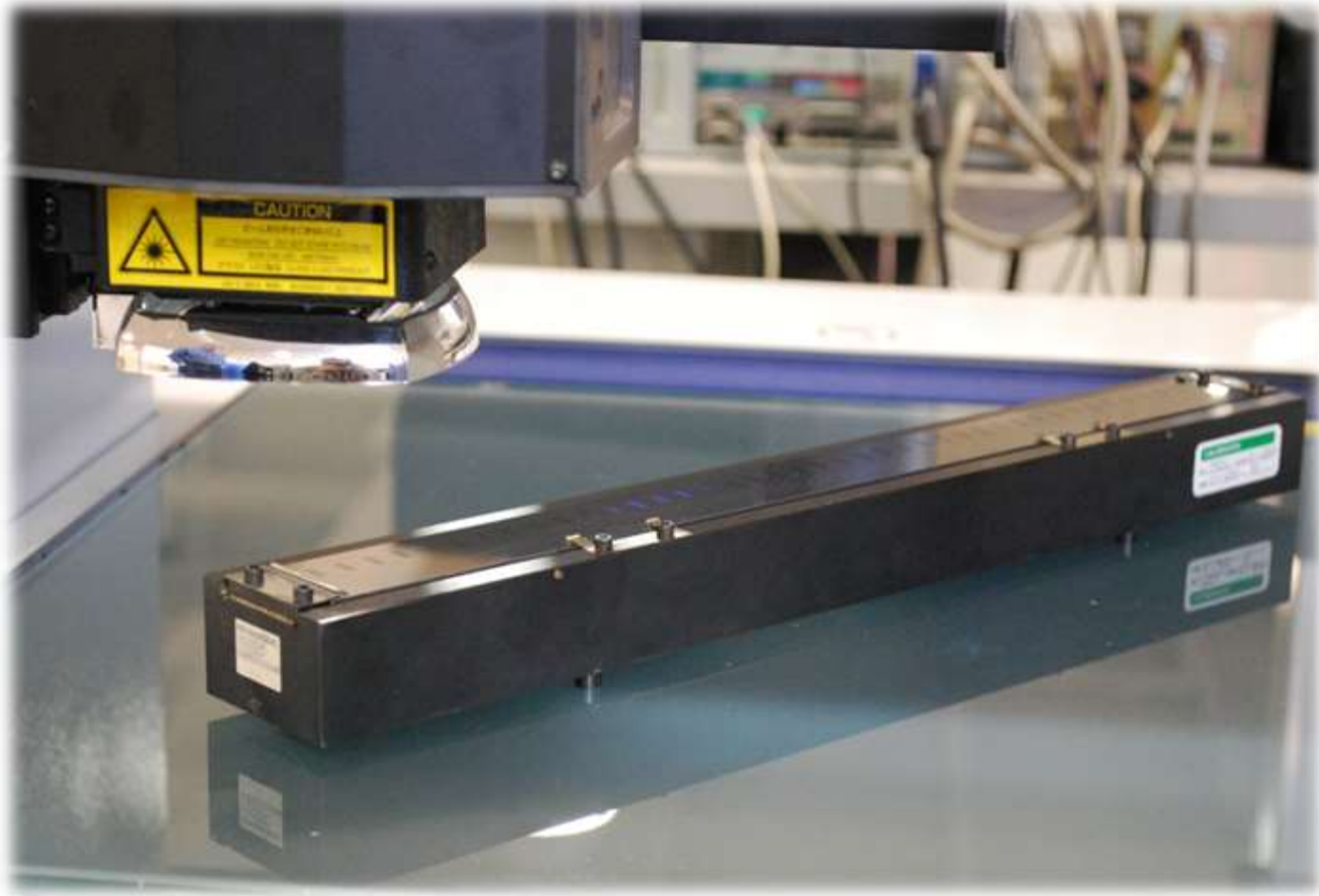
The new ISO 10360-7 applies well-developed contact probe CMM testing methods to a “CMM equipped with an imaging probing system”



## ISO 10360-2:2009 standard Length Measurement, $E_0$

- Fundamental length test for CMMs with contact probe.
- Typical specification:
  - $E_{0,MPE} = 1.9 + 3L/1000 \mu\text{m}$
- $E_0$  test run in 7 positions. In each position, 5 lengths and 3 runs of each, for a total of 105 measurements.
- Could similar testing methods be developed for vision systems?

# Using a linescale to check length errors in XY plane

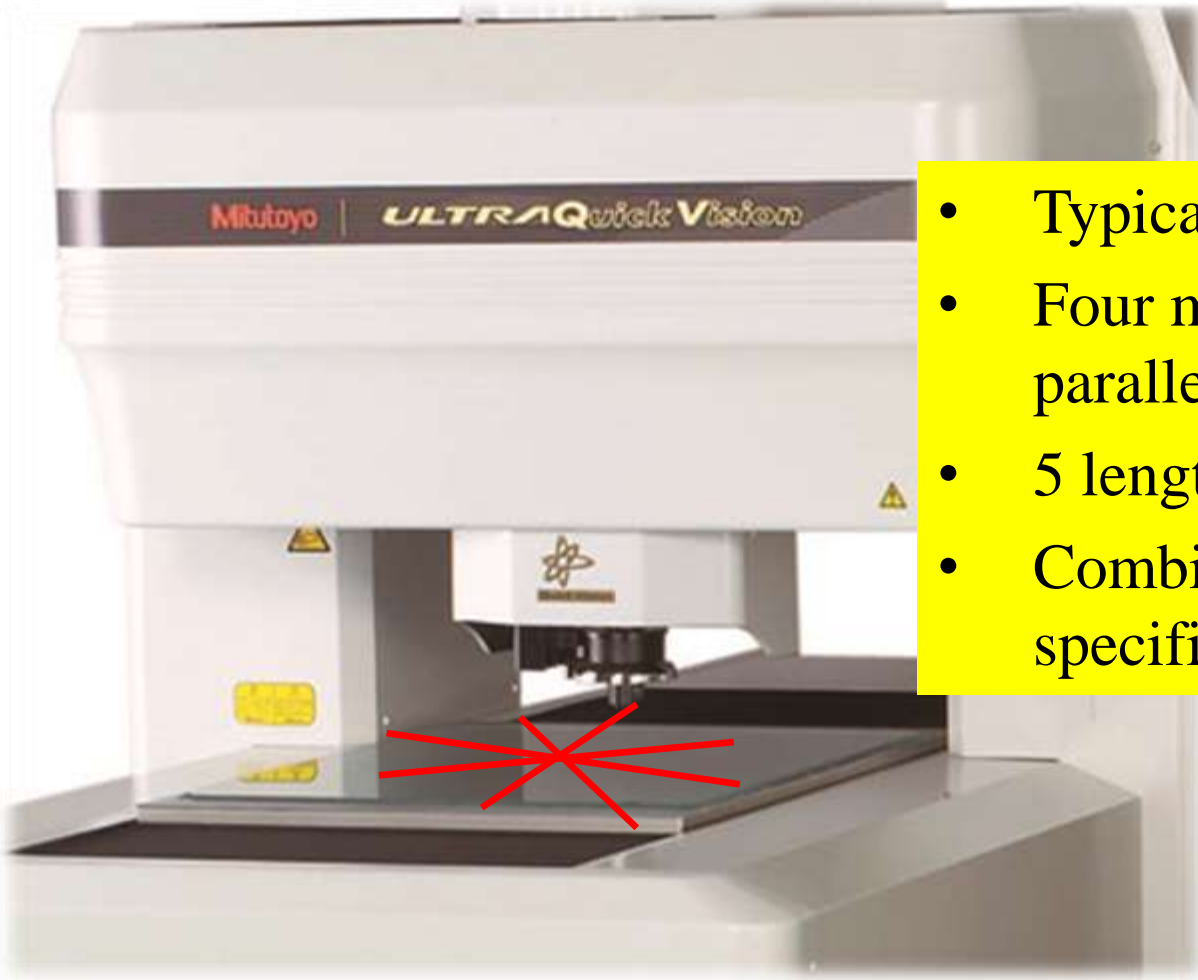


# Two Optional Approaches in ISO 10360-7:2011

- Composite Approach
  - Single 3D specification
  - Useful when comparing to contact probe CMMs
  - Does the user need or want a 3D specification?
  - Challenges in testing
- Component Approach
  - Based on historical best industrial practices
  - Preserve legacy of specifications
  - XY plane linears
  - Z axis linear and square

For either approach, there is also an important new “Probing Test” plus two optional tests when measuring only in the field of view.

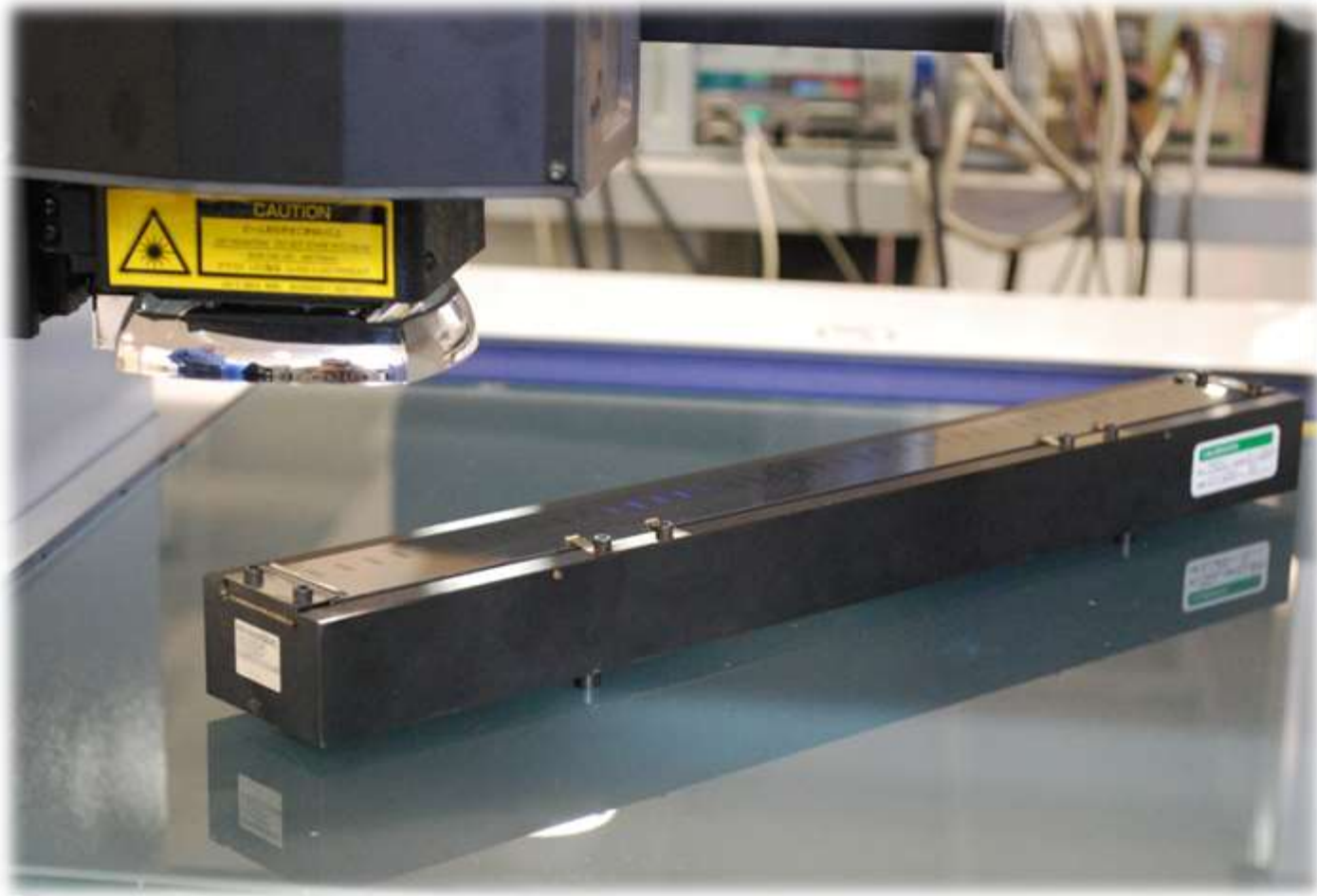
# ISO 10360-7 2-D length test: $E_{UXY}$ and $E_{BXY}$



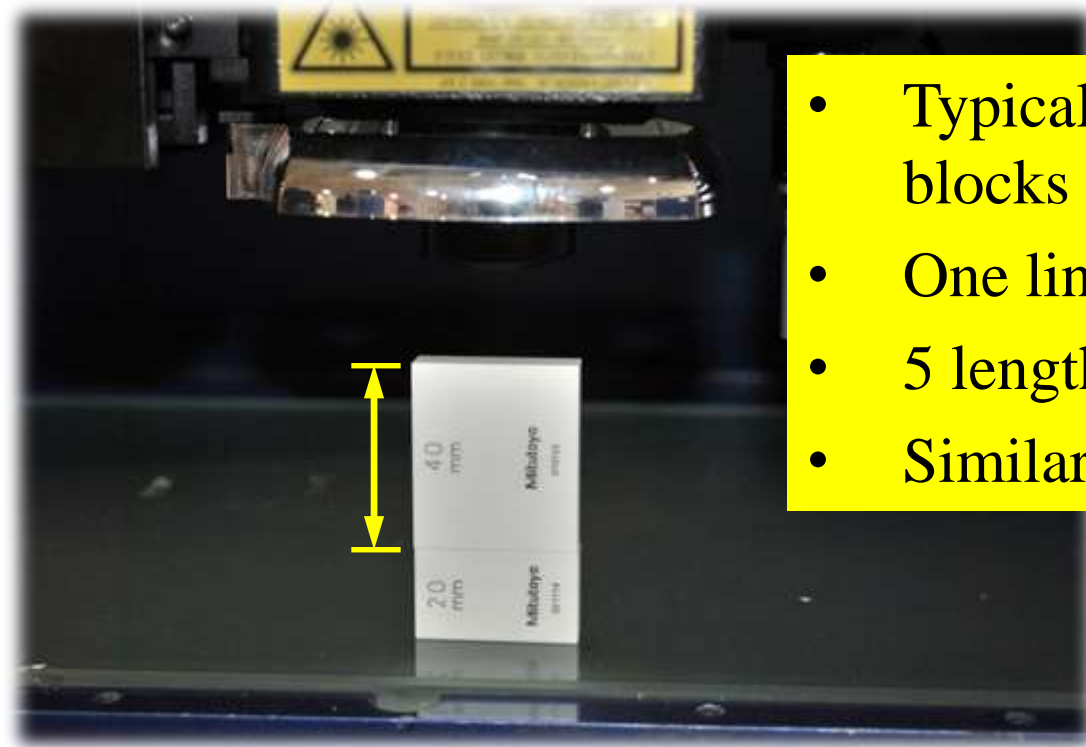
- Typical test artifact: linescale.
- Four measurement lines parallel to XY plane.
- 5 lengths, 3 repeats, 60 values.
- Combination of historical specifications  $E_{1XY}$  and  $E_{2XY}$



# Example of Checking $E_{UXY}$



# ISO 10360-7 1-D length test: $E_{UZ}$ (or $E_{BZ}$ )

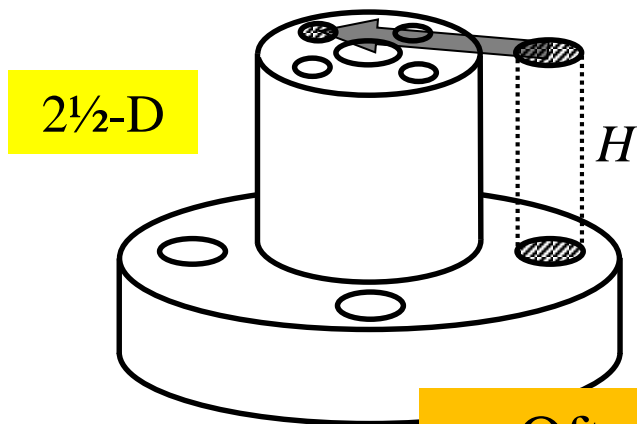


- Typical test artifact: gage blocks or stair step gage.
- One line parallel to Z axis.
- 5 lengths, 3 repeats, 15 values.
- Similar to historical  $E_{1Z}$

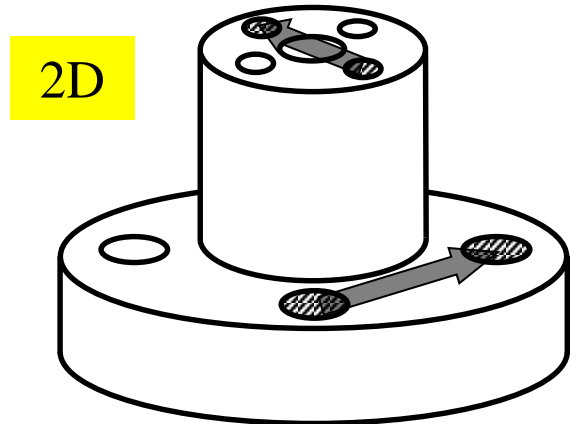
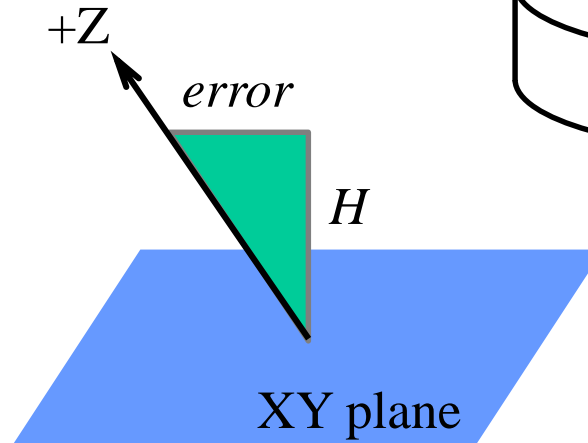


# Z-axis Straightness/Squareness to XY Plane, $E_{SQ}$

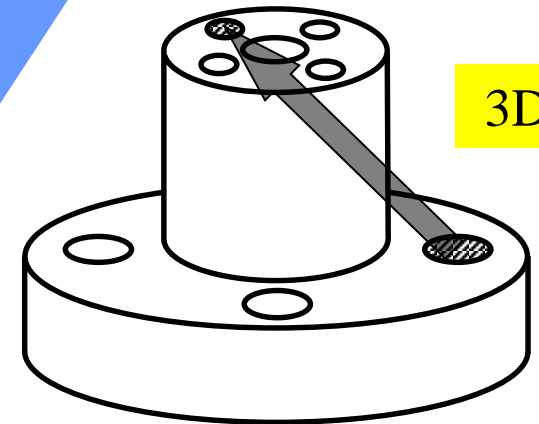
- 2½-D common with vision systems.
- When moving in Z, lateral error motion causes XY errors.



2½-D



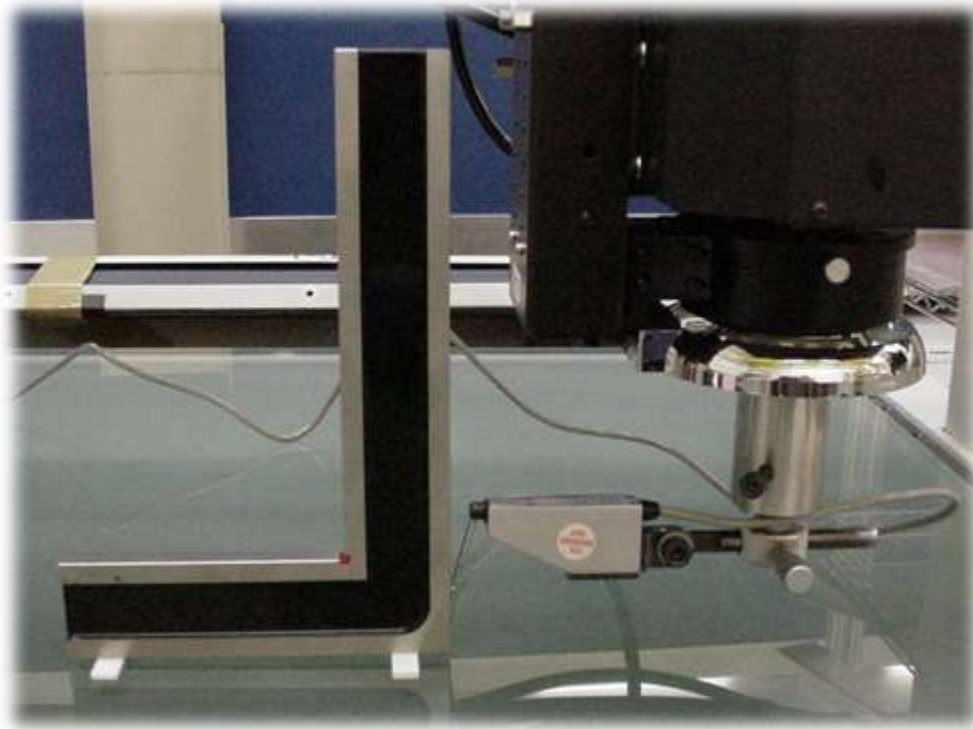
2D



3D

Often not checked!

# ISO 10360-7 Squareness Test: $E_{SQ}$



Test both:

- XZ squareness
- YZ squareness

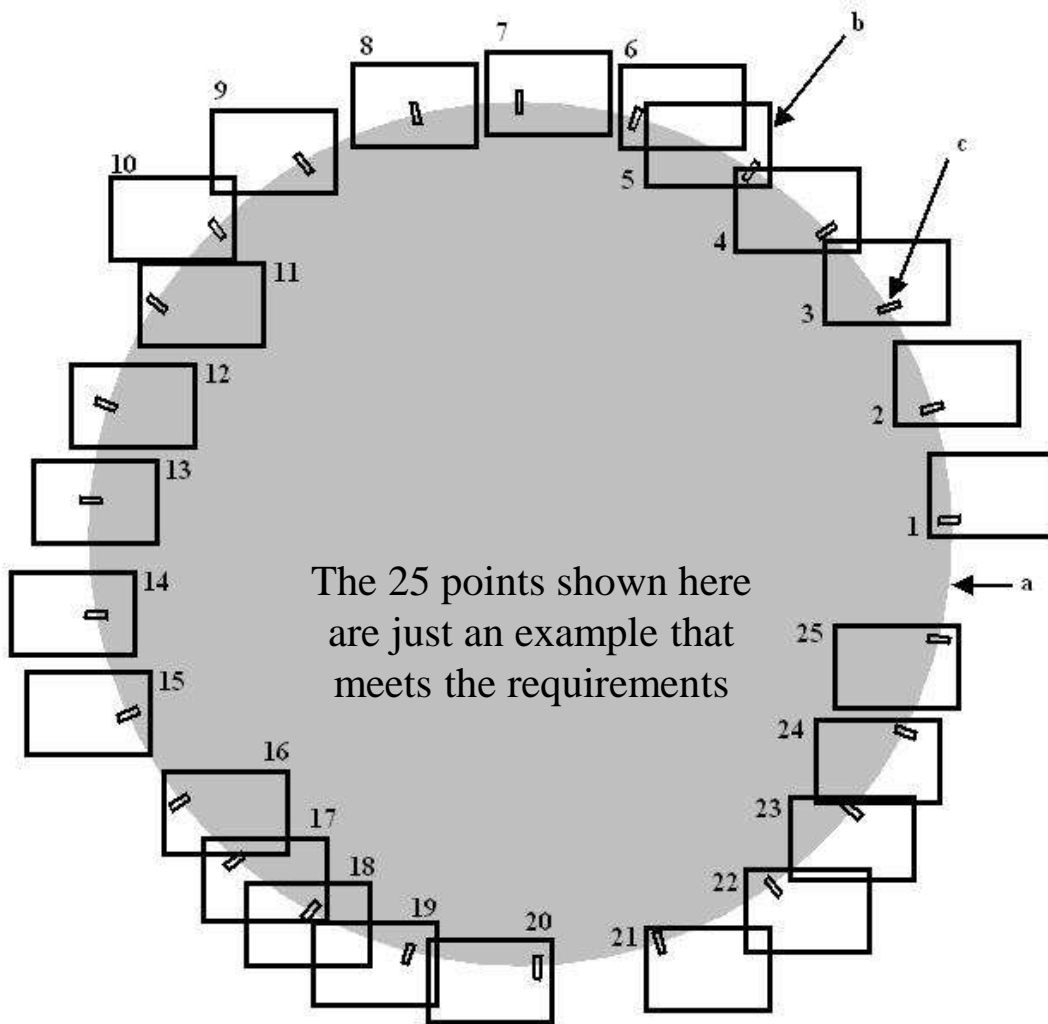
May be tested without using the probe.

# ISO 10360-7 3-D length test: $E_U$ or $E_B$

- $E_B = E_0$  for contact probes.
  - Useful for comparison between contact and video probing CMMs.
- Requires 3D testing using the vision probe.
  - Rarely used today.
  - Challenging setup, such as an inclined linescale.
- Does a single 3D specification meet typical user needs?



# ISO 10360-7 Probing Test: $P_{F2D}$



The 25 points shown here are just an example that meets the requirements

a Test circle  
b Field of view  
c Measuring window

Test requires machine motion

- How good is the vision probing system?
  - Hardware, e.g. optics.
  - Setup, e.g. camera alignment.
  - Software, e.g. edge detection.
- Mostly ignored today!
  - Errors usually not significant on lower accuracy stages.
  - Possible problem on higher accuracy systems.
- $P_{F2D}$ : one large circle.
  - Measure 25 points across the field of view (FOV).
  - Evaluate form (roundness).

# Artifact for Checking $P_{F2D}$

- Need accurate (round) 2-D circle artifact.
  - Possibly under  $0.1 \mu\text{m}$ .
- Must be calibrated for the roundness.
  - Presents a new challenge to the calibration business.



# Specifications and Symbols

- Component Approach:
  - XY plane:  $E_{UXY}$  or  $E_{BXY}$
  - Z axis:  $E_{UZ}$  or  $E_{BZ}$
  - Squareness:  $E_{SQ}$
- Probing test:  $P_{F2D}$
- Optional 2D field of view tests:
  - Length:  $E_{UV}$  or  $E_{BV}$
  - Probing:  $P_{FV2D}$
- Composite Approach:
  - 3D testing:  $E_U$  or  $E_B$
  - Repeatability:  $R_U$  or  $R_B$

Manufacturer specifications are listed as maximum permissible errors (MPE), for example:

- $E_{UXY, MPE} = 0.5 + 2L/1000 \mu\text{m}$
- $E_{SQ, MPE} = 2.5 \mu\text{m}$

The B and U in  $E_B$ ,  $E_{UXY}$ , etc., refer to the type of artifact (unidirectional or bidirectional) and either may be used at the discretion of the manufacturer.



Test	Historical Specifications	New Specifications	
		Parameter	ISO Standard
Length parallel to X or Y axis	$E_{1XY}$ or $U_{1XY}$	$E_{UXY,MPE}$ or $E_{BXY,MPE}$	ISO 10360-7
Length diagonals in XY plane	$E_{2XY}$ or $U_{2XY}$		
Length parallel to Z axis	$E_{1Z}$ or $U_{1Z}$	$E_{UZ,MPE}$	ISO 10360-7
Squareness of Z to XY	Unpublished specifications	$E_{SQ,MPE}$	ISO 10360-7
Volumetric (composite)	Nothing	$E_{U,MPE}$ or $E_{B,MPE}$	ISO 10360-7
Probe test, vision probe	Nothing	$P_{F2D,MPE}$	ISO 10360-7
Volumetric with touch probe (multi-sensor CMM)	Not used	$E_{0,MPE}$	ISO 10360-2
Probe test, touch probe (multi-sensor CMM)	Not used	$P_{FTU,MPE}$	ISO 10360-5

# Questions?

INTERNATIONAL  
STANDARD

ISO  
10360-7

First edition  
2011-06-01

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**Geometrical product specifications  
(GPS) — Acceptance and reverification  
tests for coordinate measuring machines  
(CMM) —**

Part 7:  
**CMMs equipped with imaging probing  
systems**



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