Always above Standard

We make it visible.

Carl Zeiss Industrial Metrology

Algorithms

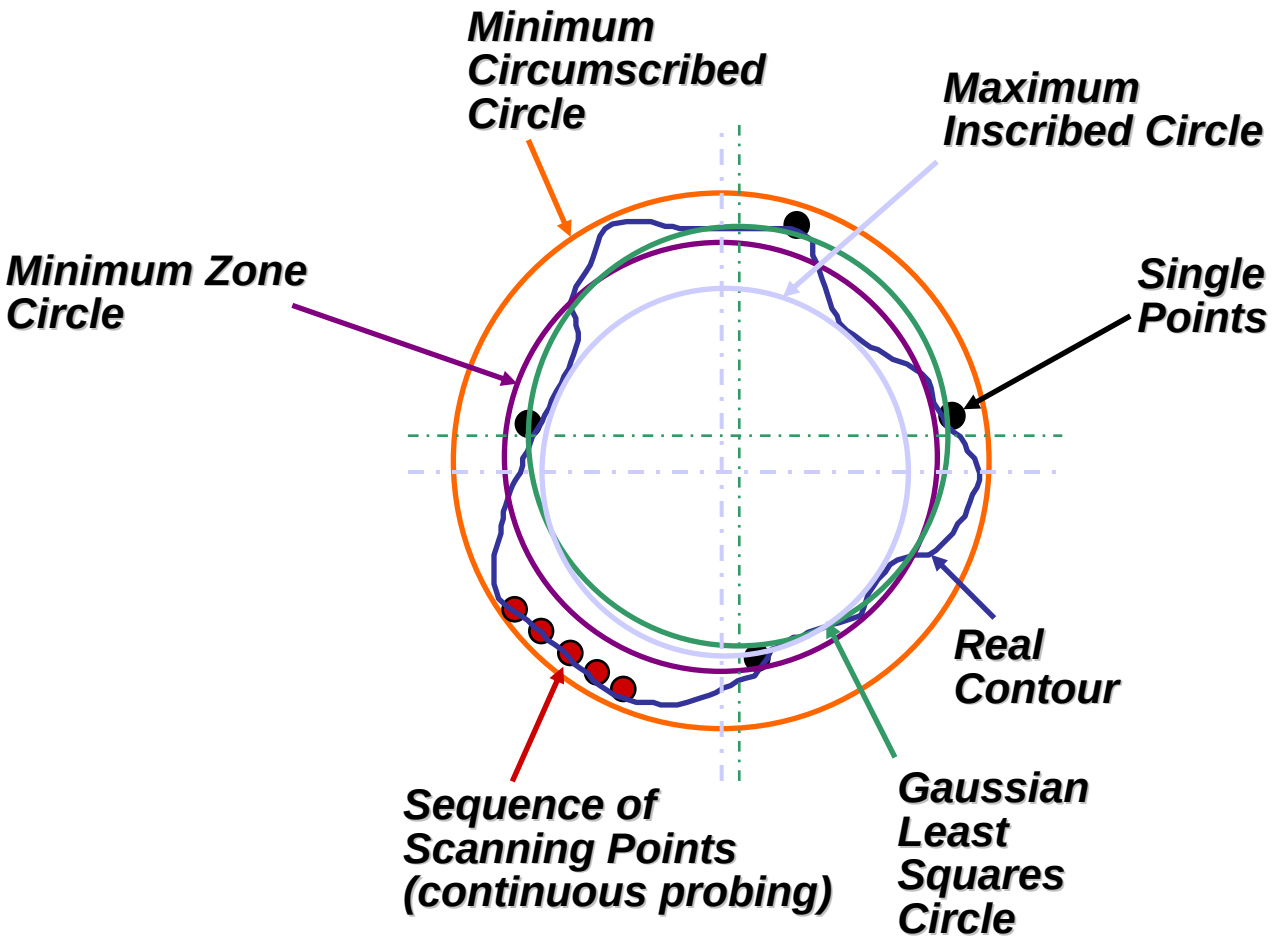
July 2003

Engineering Conference

Richard Knebel

Algorithms

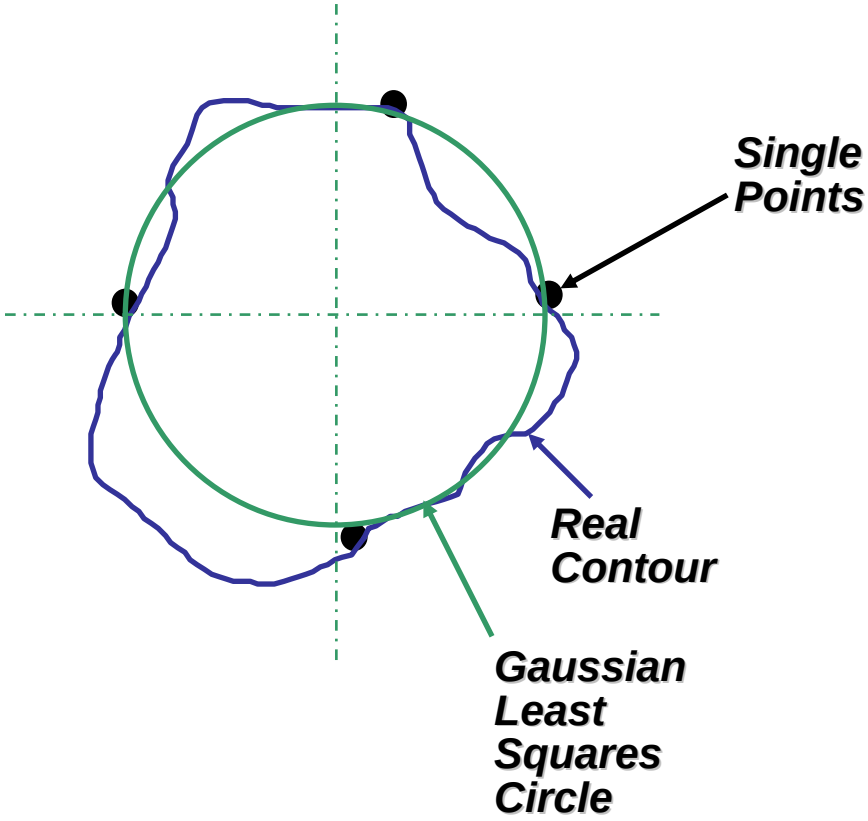
We make it visible.



Why Least Squares ?

We make it visible.

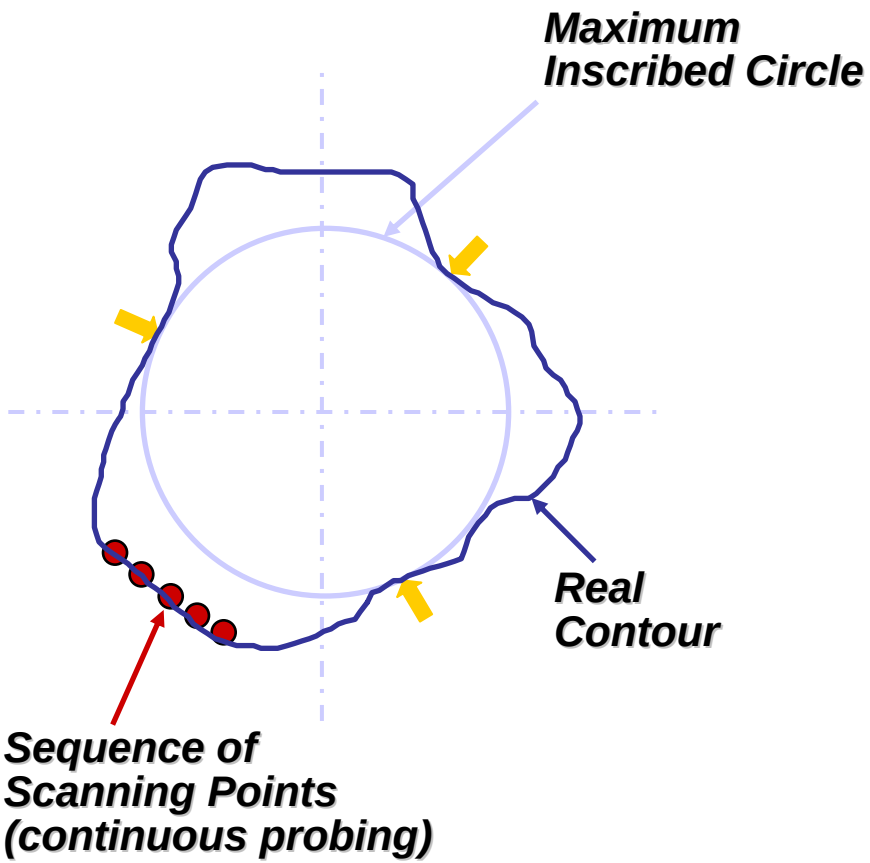
- **Provides a consistent, stable result**
- **Consistently provides the**
  - **Wrong Size**
  - **Wrong Location**
  - **Wrong Form**



Why Maximum Inscribed ?

We make it visible.

- **Provides the correct result for**
  - **Size**
  - **Location**
- **On *internal* diameters**
- **When used with enough data density**
- **However it is not as stable a Least Squares because ??**
  - **It fits on extreme points**



Why Minimum Circumscribed ?

We make it visible.

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  - **Location**
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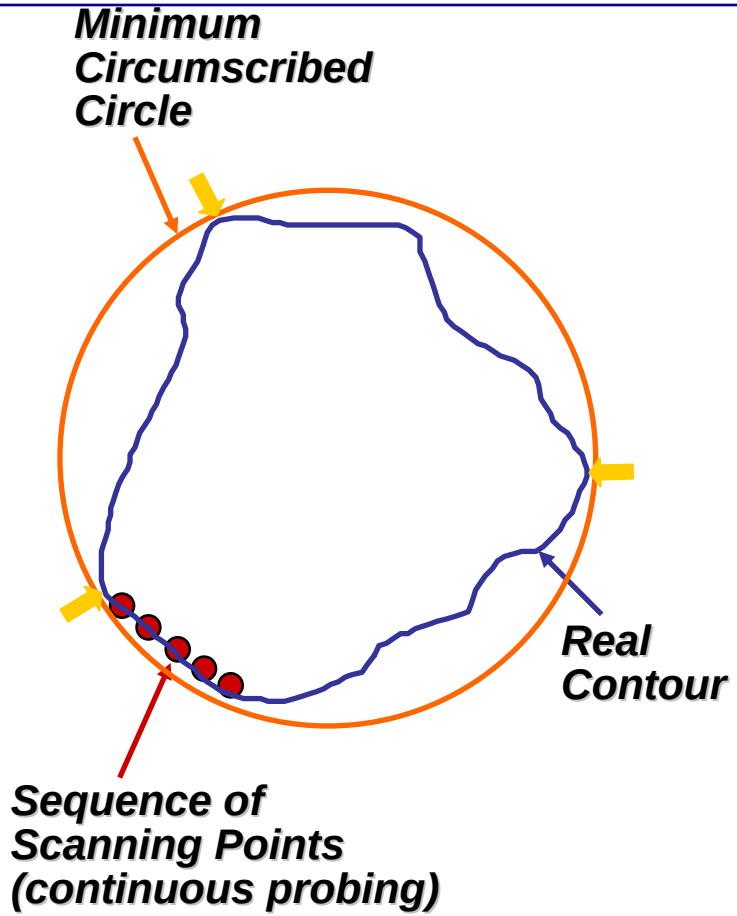

Why Minimum Zone ?

We make it visible.

- **Provides the correct result for**
  - **Form**

- **When used with enough data density**

- **However it is not as stable a Least Squares because ??**
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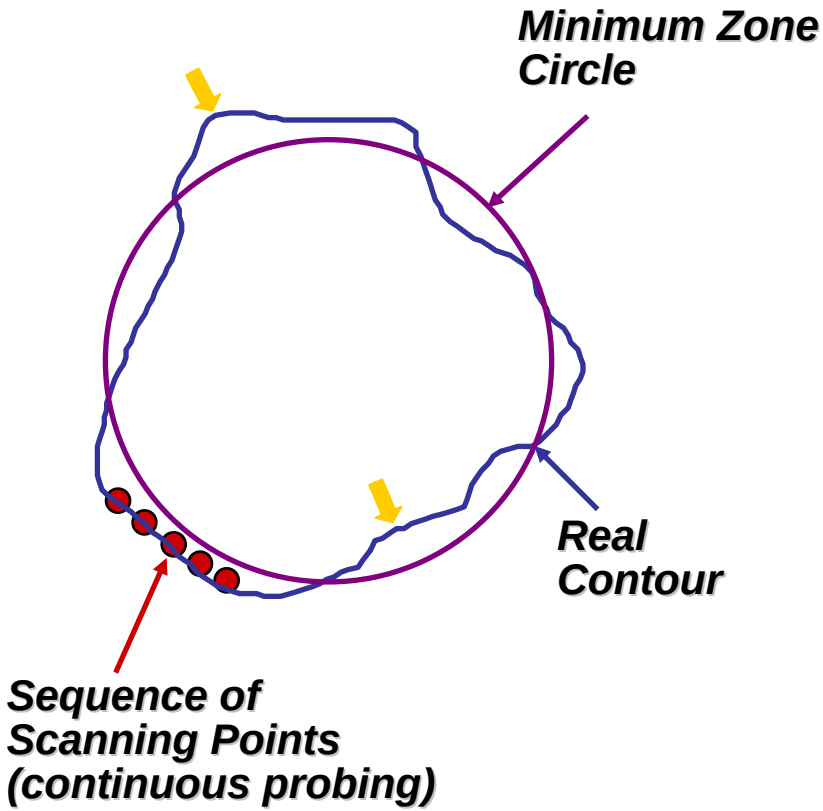
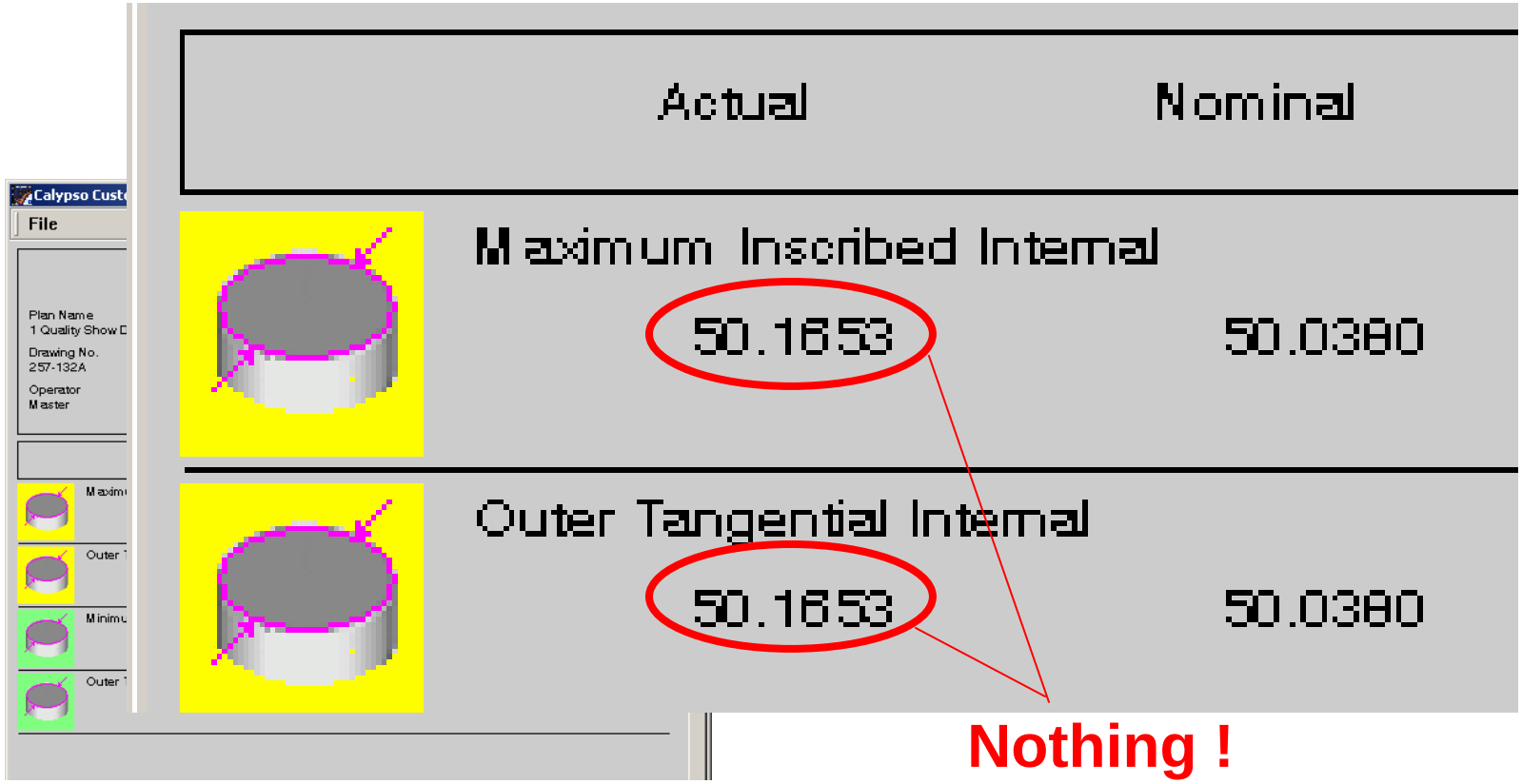


What about Inner and Outer Tangential ?

We make it visible.

- **What's the difference between Outer Tangential and Maximum Inscribed on an *internal* diameter ?**



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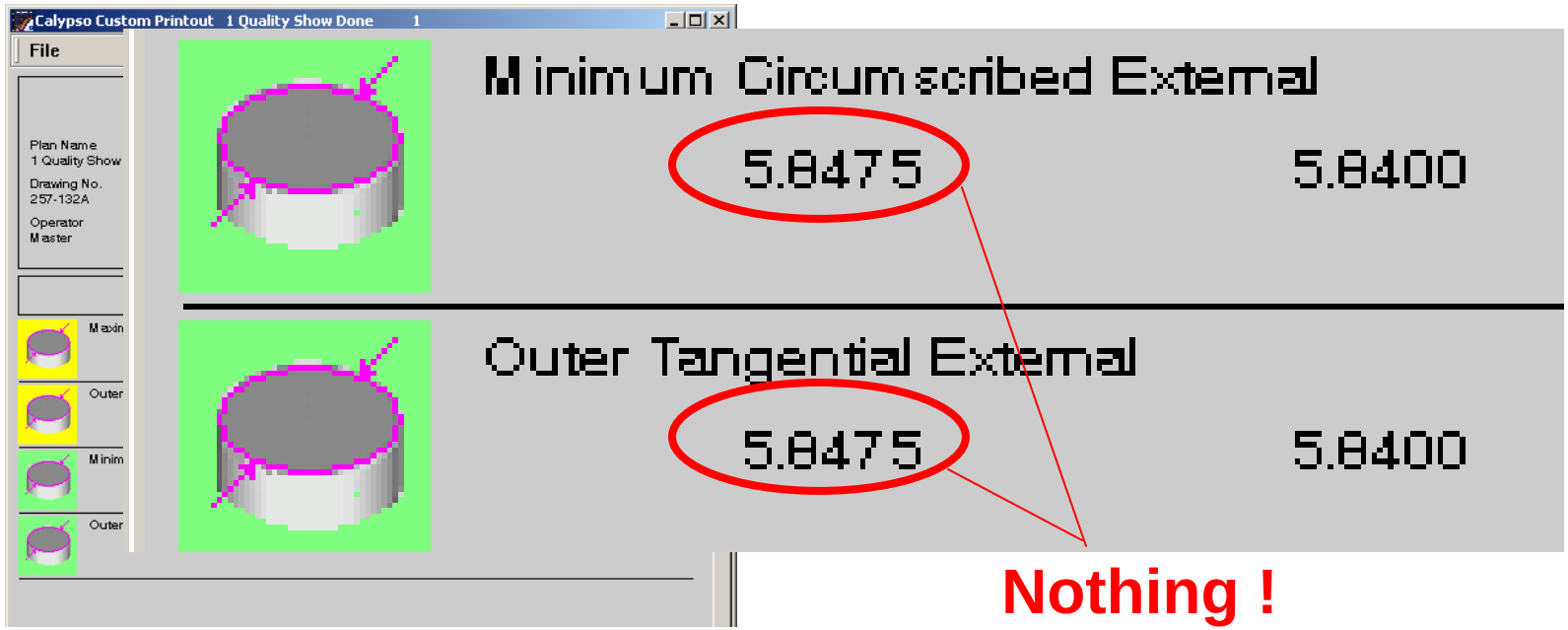
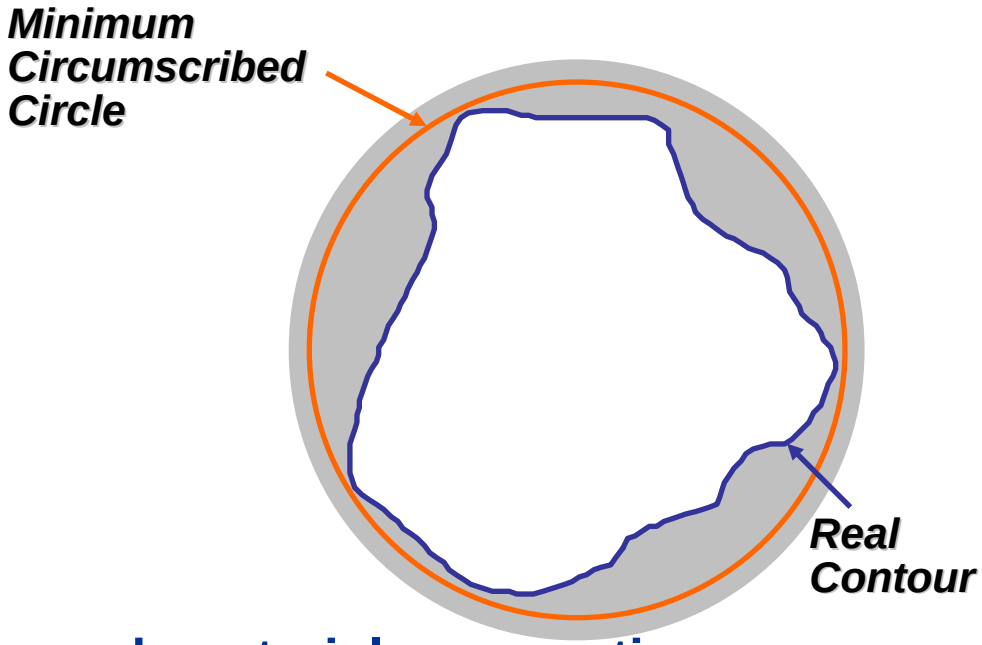


What about Inner and Outer Tangential ?

We make it visible.

- What's the difference between Inner Tangential and Minimum Circumscribed on an ***internal*** diameter ?
- Nothing !
- Is this functional ?
- No !
- When might you use it ?



- To determine if there is enough material on a casting so that it will cleanup during machining or to evaluate wall thickness

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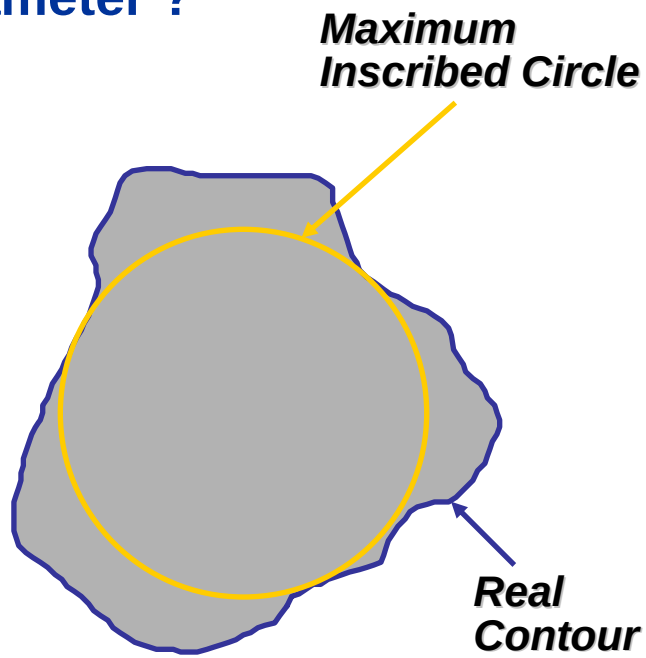

So why do we have Inner and Outer Tangential ?

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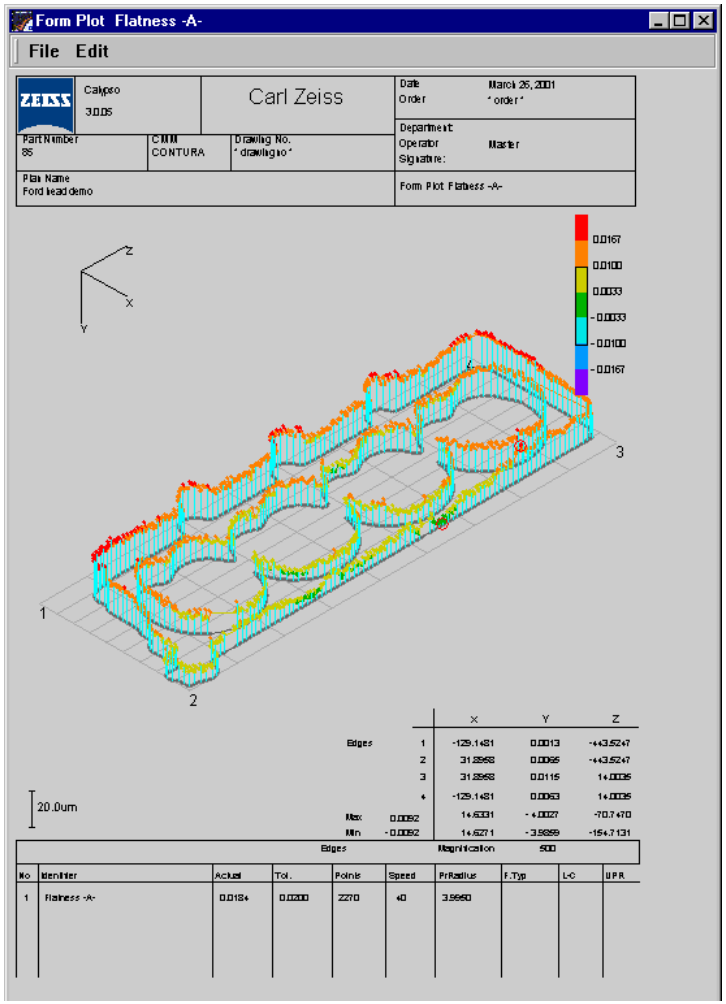
- **Because it is more descriptive for Planes and Lines**



So lets generalize the math

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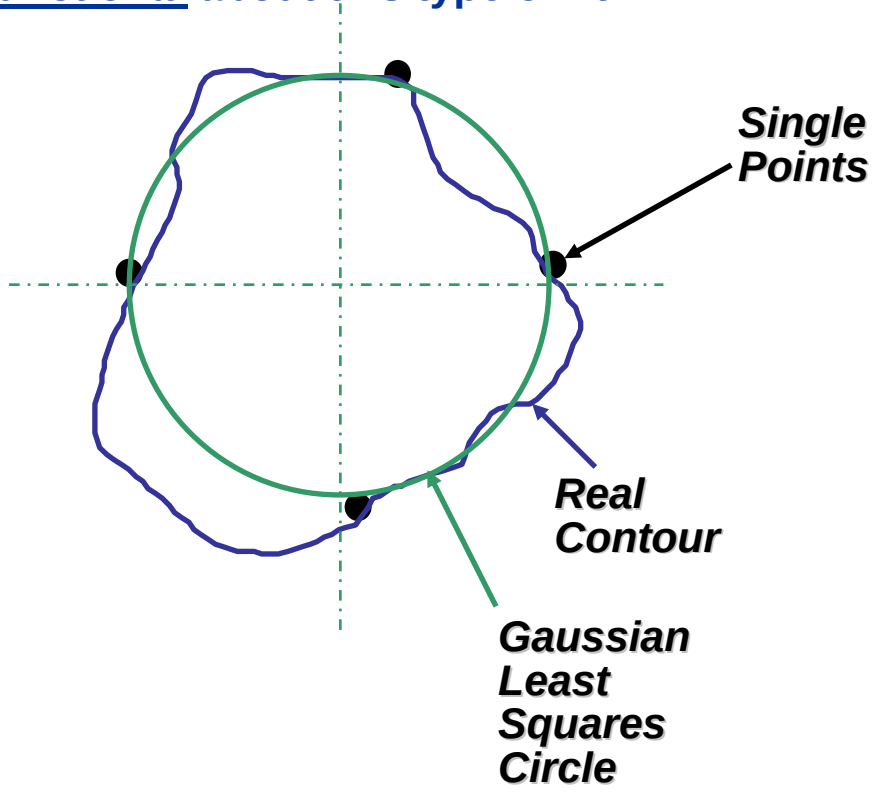
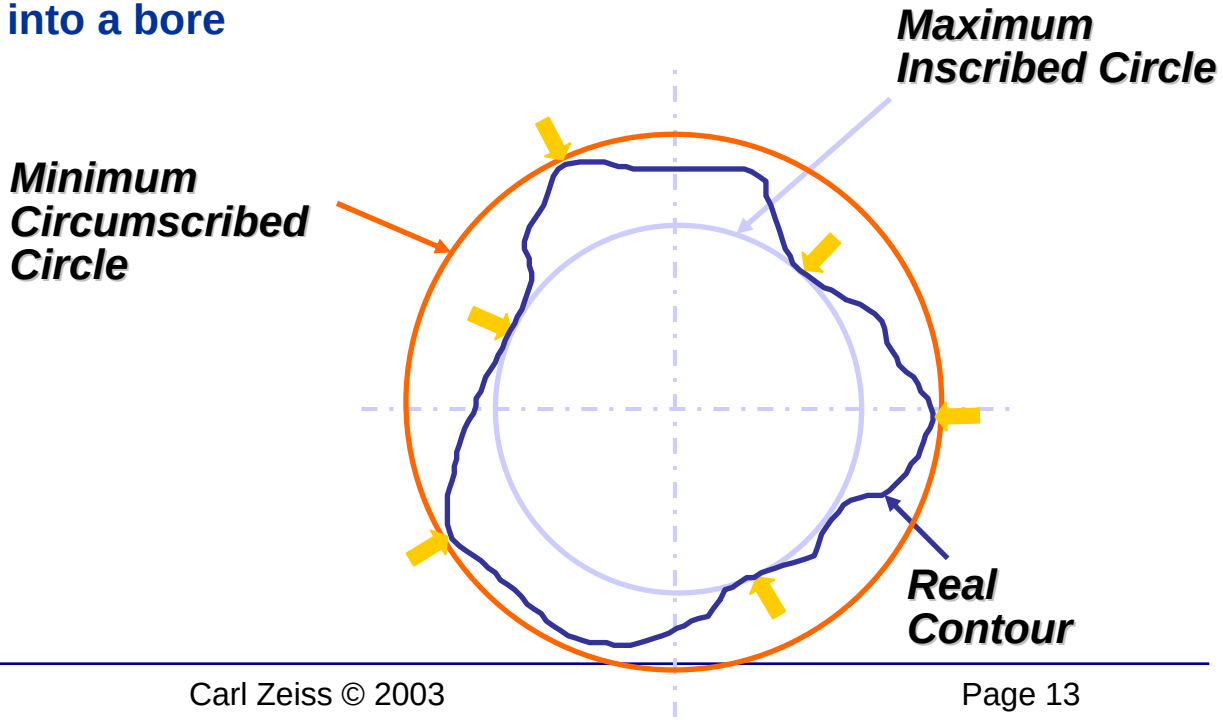
- **We have Gaussian Least Squares fits which minimize the square root of the sum of the squared errors**
  - **In this type of fit all data points have the same weight in determining the fit**
  - **There is *absolutely nothing functional* about this type of fit**



So lets generalize the math

We make it visible.

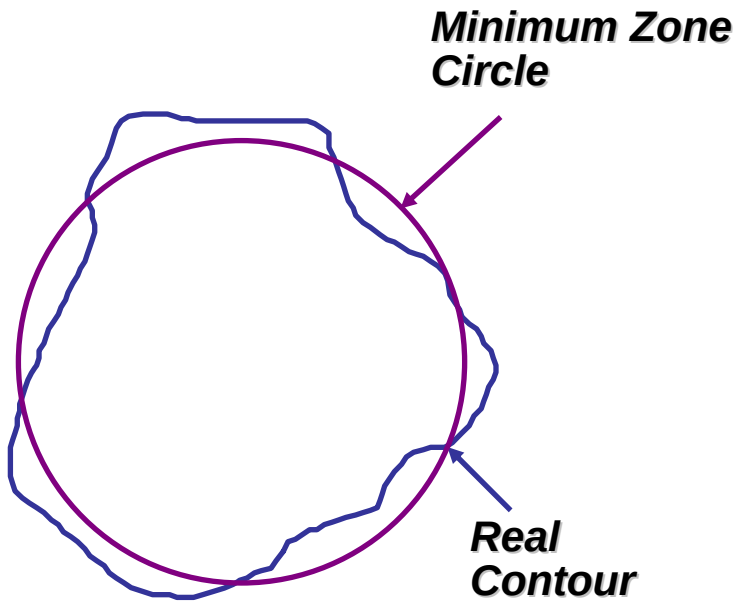
- **We have *extrema* fits (Inner and Outer Tangential, Max Inscribed, Min Circumscribed) which fit on the high points of the feature**
  - **In this type of fit only the high points have any weight in determining the fit**
  - **This is *absolutely functional* fitting for size and location like when mating a plane against a granite surface plate, or finding the slip fit pin that just fits into a bore**



So lets generalize the math

We make it visible.

- **We have *minimum zone* fits which equally balance the high and low point of the feature**
  - **In this type of fit only the high point and low point have any weight in determining the fit**
  - **This is *absolutely functional* fitting for form analysis**



Summary

We make it visible.

- Know the basic best use of each algorithm
- Understand the potential difference (pros and cons) each algorithm can provide
- Apply the algorithm that meets the needs of the customer and application accordingly
- There is no one simple rule that can define what to use when, as an Applications Engineer you must help decide what is best on a case-by-case basis