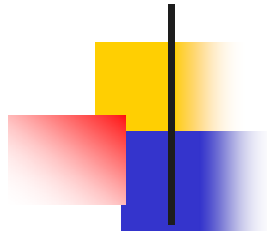


Capacitec

Best Practices in the use of "Smart" Displacement, Gap and Hole Sensors for Aircraft Engine test and overhaul

*Presented by
Bryan Manning/ Commercial Director
Capacitec*

*Aerospace Testing Expo Long Beach, CA
November 8, 2005*



Capacitec Background

- ◆ Over 20 years of Aerospace Market Experience in The US, Europe and Japan
- ◆ Customers include: GE, P&W, Boeing, Lockheed, Voight, SNECMA, MTU, Airbus, Rolls Royce, Lufthansa, Air France...
- ◆ Unique leading technology in non-contact capacitive displacement, gap and hole measurement sensors and systems
- ◆ Industry leading small sensor size vs. large range, extreme environments to 1000°C and high magnetic fields



Aircraft Engine Applications

- ◆ Engine rebuild concentricity
- ◆ Fan blade clearance
- ◆ Engine maintenance assessment
- ◆ High temperature thermal expansion
- ◆ Blade tip gap measurement
- ◆ Measurement of bore diameters



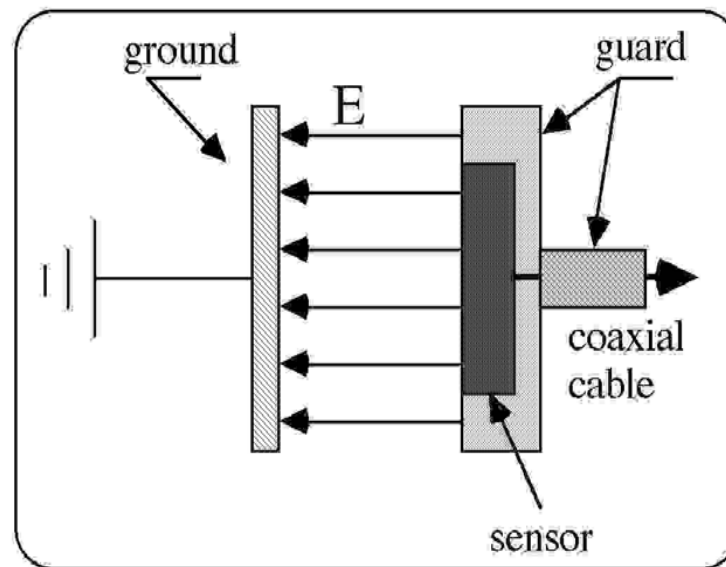


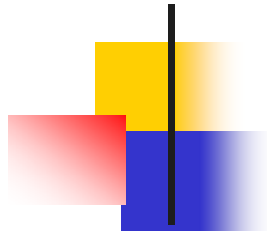
Aircraft Applications



Principle of non contact capacitive measurement

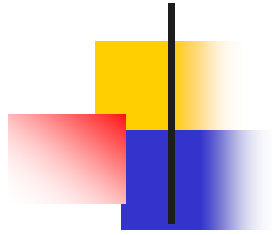
- ◆ Capacitive reactance is proportional to the distance between the sensor and the target



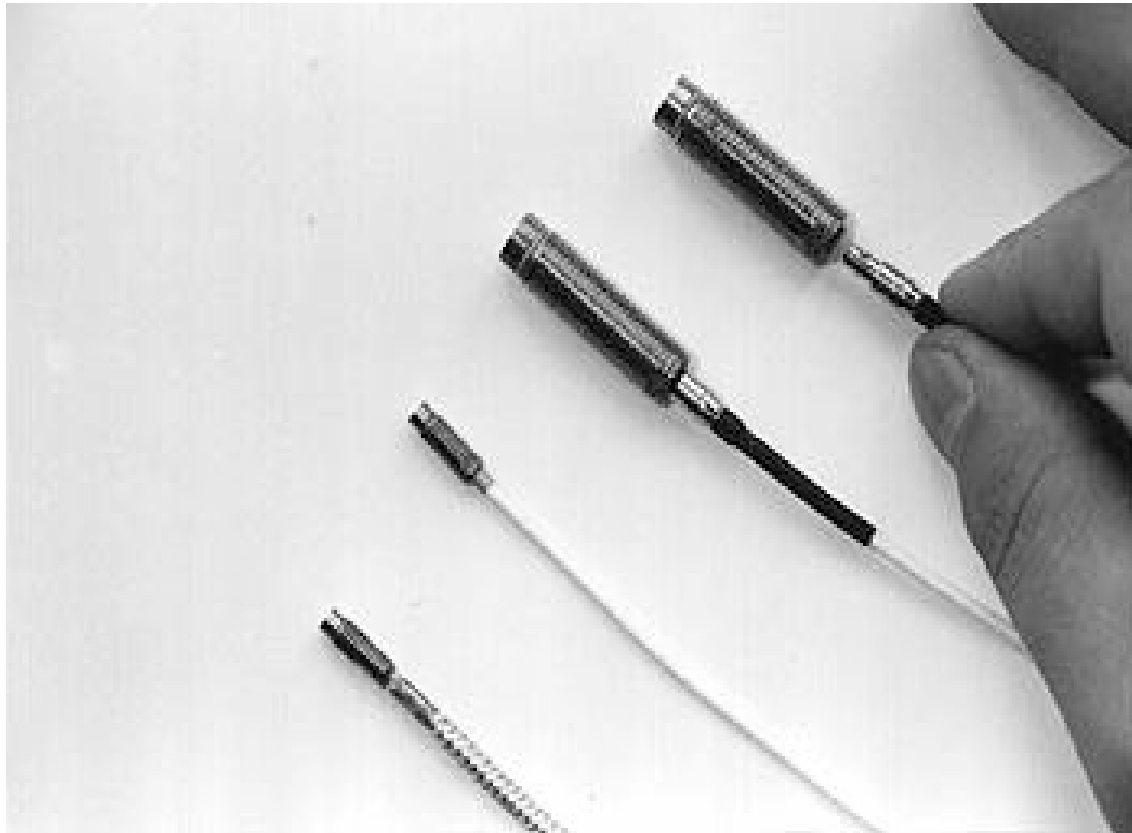


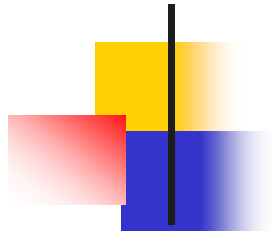
Displacement measurement

- ◆ High resolution combined with very small probe sizes (2 mm OD)
- ◆ High precision with linearity to 0.1% FS and repeatability to 0.01% FS
- ◆ Extreme temperature: Cryogenic (-272°C) to 1000°C
- ◆ High frequency response for high temperature and fatigue testing
- ◆ Blade length balance testing



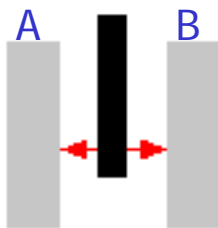
Typical displacement sensors





Gap measurement

- ◆ Gap measurement range from 0.23 mm to 6 mm
- ◆ Handheld portable instrumentation: Gapman and Gapmaster 3.
- ◆ Complete line of standard and custom wand sizes
- ◆ Complete solutions: sensor wand, electronics, data acquisition and display software



A, B = metal or composite





Portable “Electronic Feeler Gage”



Capacitec

P.O. Box 819 Ayer, MA 01432

Tel: 978 772 6033

email: sales@capacitec.com

Portable/Precise Gapping System





Hole/Bore/Taper measurement

Easy to use in all aircraft environments.





Hole/Bore/Taper measurement

- ◆ System conforms to Aerospace precision and quality control requirements
- ◆ Specialized in measuring complex tapered holes
- ◆ Qualified tool at Airbus: Hamburg, Nantes, Toulouse, Bristol etc. , as well as at Boeing and Lockheed.

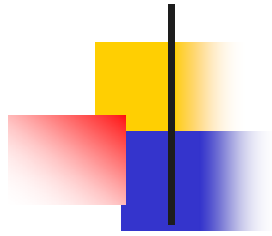




Aircraft Engine Applications

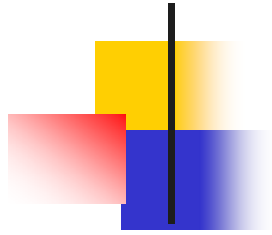
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Engine Rebuild Concentricity

- ◆ ~8 mm sensor attached to end of blade in HPC or HPT stage of CFM56 engine with lead exiting through inspection bore scope hole.
- ◆ The rotor is rotated 360° to measure the gap between the blade tip and housing circumference
- ◆ Displacement values sent to custom software program which polar plots deviation of the blade assembly's concentricity
- ◆ Out of spec concentricity requires technician adjustment by re-torqueing case segments



Engine Rebuild Concentricity System



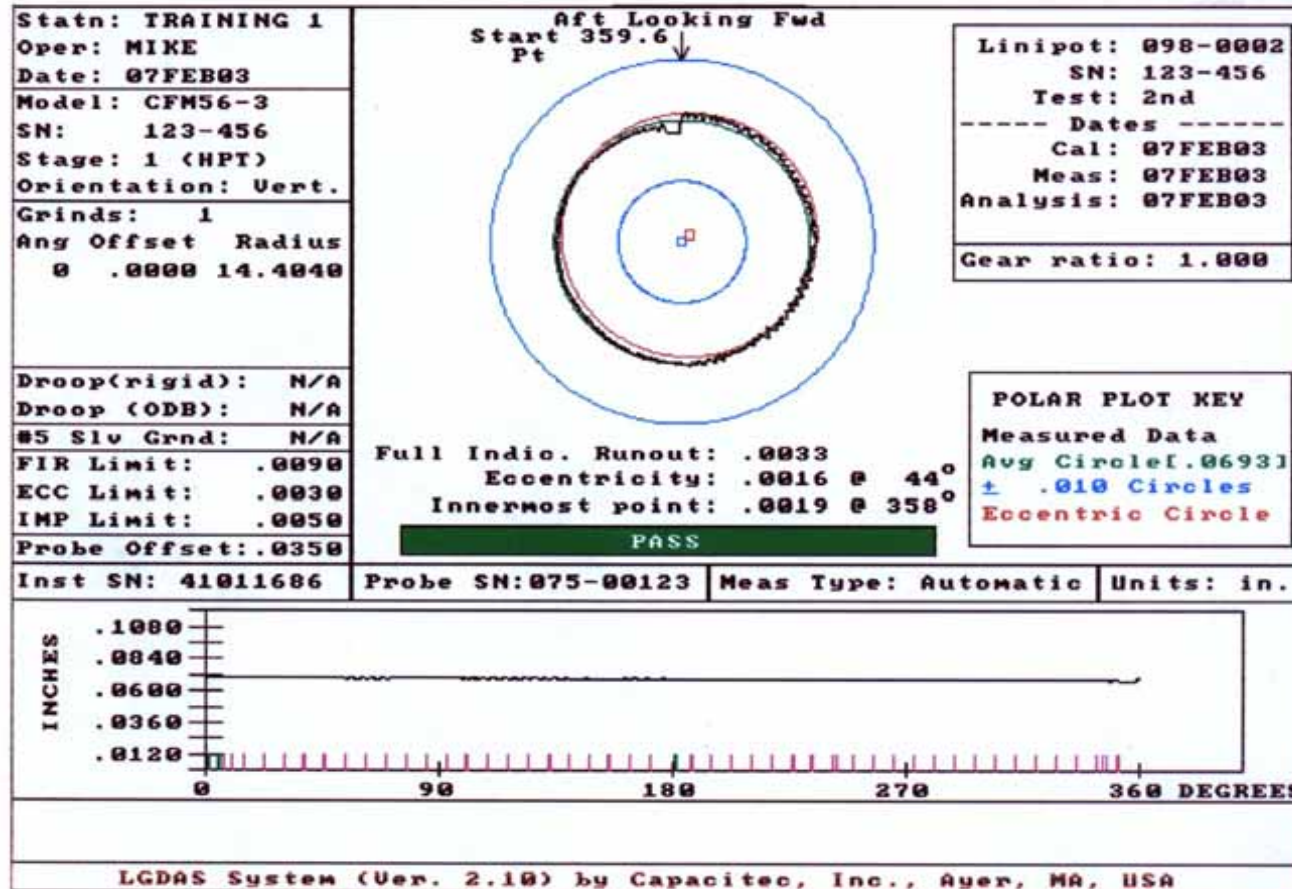
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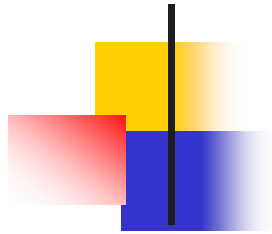
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Engine Rebuild Concentricity





Fan blade clearance

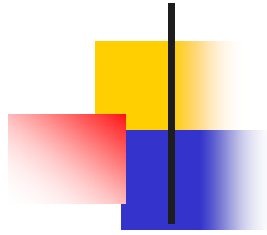
- ◆ Current mechanical gap measurement methods, step gages and shims, are very limited and fail Gage R & R.
- ◆ Capacitec has developed a special “electronic gap gage” that meets Gage R & R goals and allows quality control improvements such as Six Sigma to be attained.



Electronic Fan Blade Gap Measurement

Advantages over contact methods

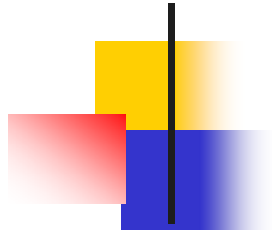




Fan blade gap tool



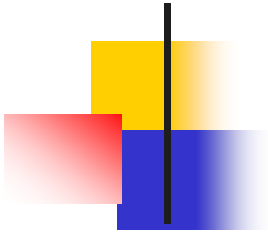
Maintenance Tool



Fan blade gap tool



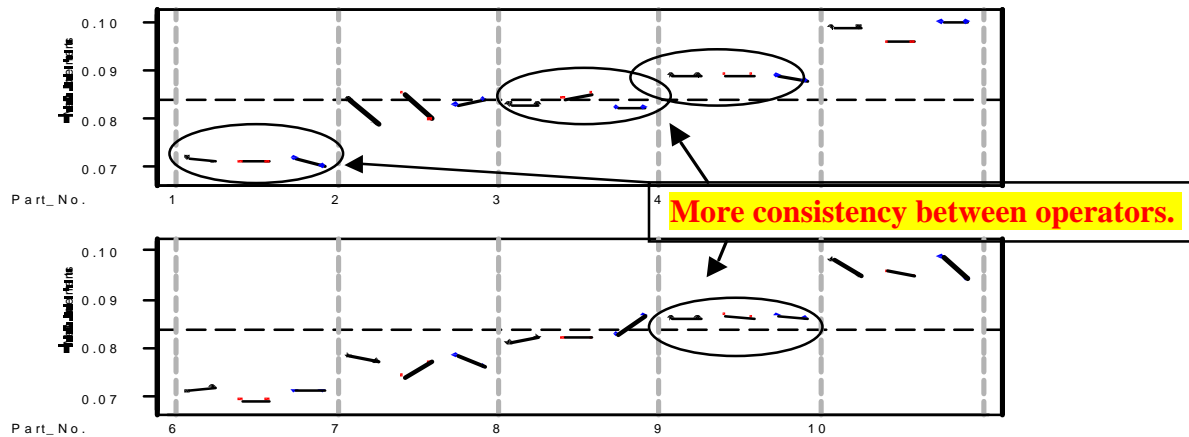
Maintenance Tool
range 0.9 to 5 mm



Fan blade clearance

Clearance_Gapman_Run_Chart

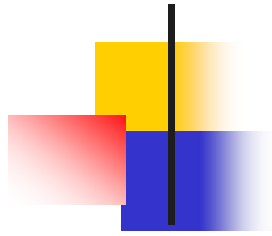
R & R Study





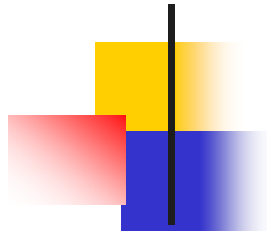
Fan blade portable gap tool





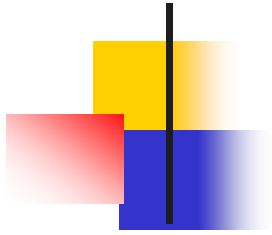
Engine Dynamic Blade Tip Clearance Measurement

- ◆ Developing “next generation” blade tip clearance probes for release in 2006
- ◆ Will meet new specification for up to 1300C on sensor face and environmental shock and vibration associated with dynamic blade tip clearance measurement.
- ◆ Associated electronics also in design review.



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