Measuring Fiber End Face Inspection Microscope Reproducibility using Chrome on Glass Artifacts

Presented at AVFOP 2017

New Orleans, LA
November 9, 2017

LOCKHEED MARTIN

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PIRA# OWG201709007

Overview

- Lockheed Martin-RMS, Cinch Connectivity, and FiberQA conducted a fiber scope repeatability and reproducibility test.
- Three FastMT-400 fiber scopes (SN 0009, 0058 and 0018) all running SW Version 2.10.9.
- Processed five MT-72 Test Targets (SN 100, A4, C1, C4 and E1).
- Acquired 32 repeat sets of images and data from each target.
- Reduced the data to estimate the particle diameter statistics.
- Estimated guard bands for reproducibility across supply chain.

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FastMT Overview

- **FastMT is a family of fiber inspection microscopes that images all (Model 200) or large portion (Model 400) of the fibers on an MT ferrule simultaneously.**
- **Fast, accurate imaging, and processing of MT fibers with:**
  - **Auto focus on all models.**
  - **Automatic Pass/Fail capability with industry standards or user defined criteria.**
- **Fixtures available for wide range of MT and Single Fiber connectors.**

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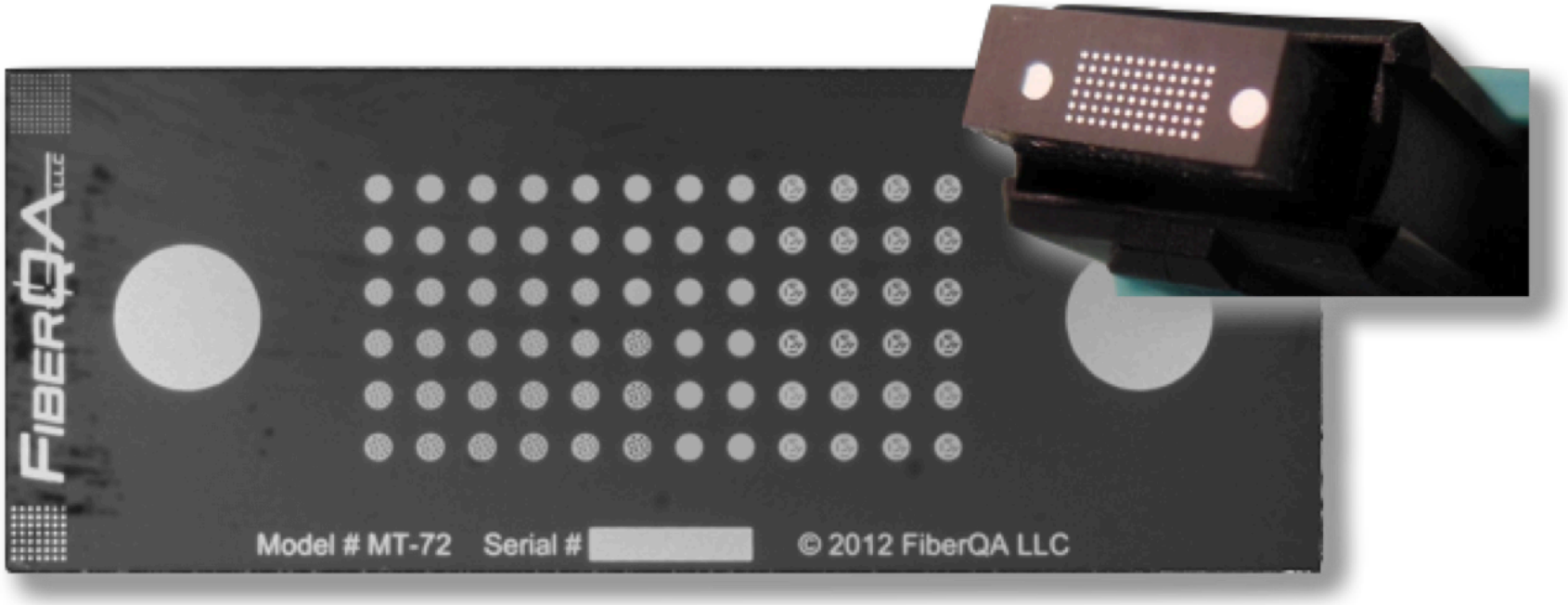
HCDD-MT-72 Test Target



- **Chrome on glass emulation of 72-fiber MT.**
- **Defects darker than background, with high contrast.**
- **Emulated fibers with particles (33), scratches (24), and no defects (15).**
- **Fibers that emulate particle defects have 16 dots at known locations.**
- **528 independent diameter estimates per test (33 fibers*16 particles/fiber).**

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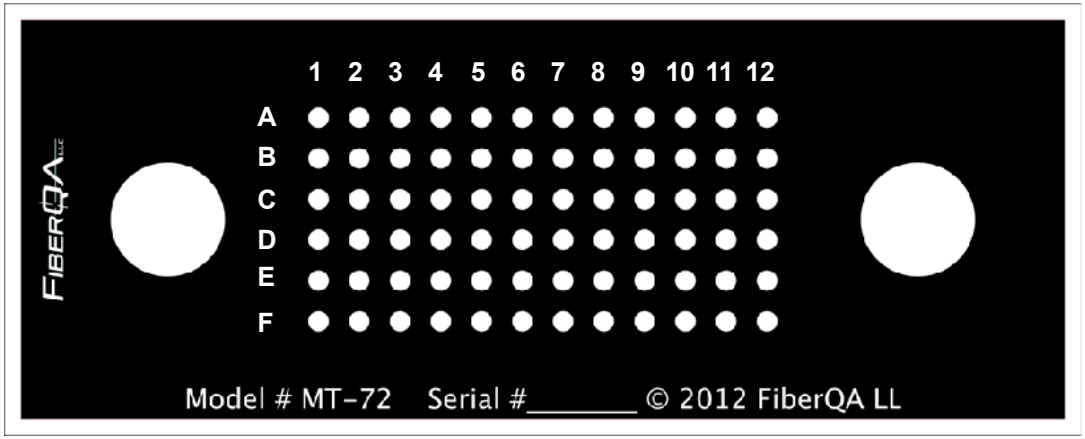
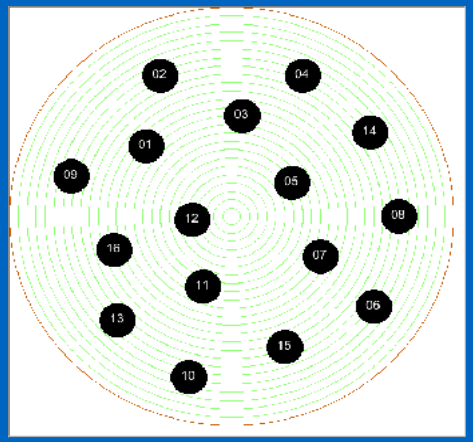
HCDD-MT-72 Ferrule, Particle Layout, and Particle Diameters



Particle Layout



Particle Sizes by Fiber

Row	Fiber 1	2	3	4	5	6
A	1.50	1.75	2.00	2.25	2.50	None
B	2.50	2.75	3.00	3.25	3.50	None
C	3.50	3.75	4.00	4.25	4.50	None
D	4.50	4.75	5.00	5.25	5.50	9.00
E	5.50	5.75	6.00	6.25	6.50	9.50
F	6.50	6.75	7.00	7.25	7.50	10.00

Results Presented as Images, Graphs, and Tables

- Sample images including raw, enhanced and overlay
- Numerical comparison data across the three FastMT's in the graphs and tables in following slides:
  - Diameter variation about the mean value plotted as min, max and StDev on an XY graph vs. nominal diameter for target SN C1's. Other target's data were similar.
  - Histographs for each FastMT of the diameter (minus mean) for all particle sizes shown as plots for each of the five targets.
  - Diameter bias error computations.
  - Guard band.

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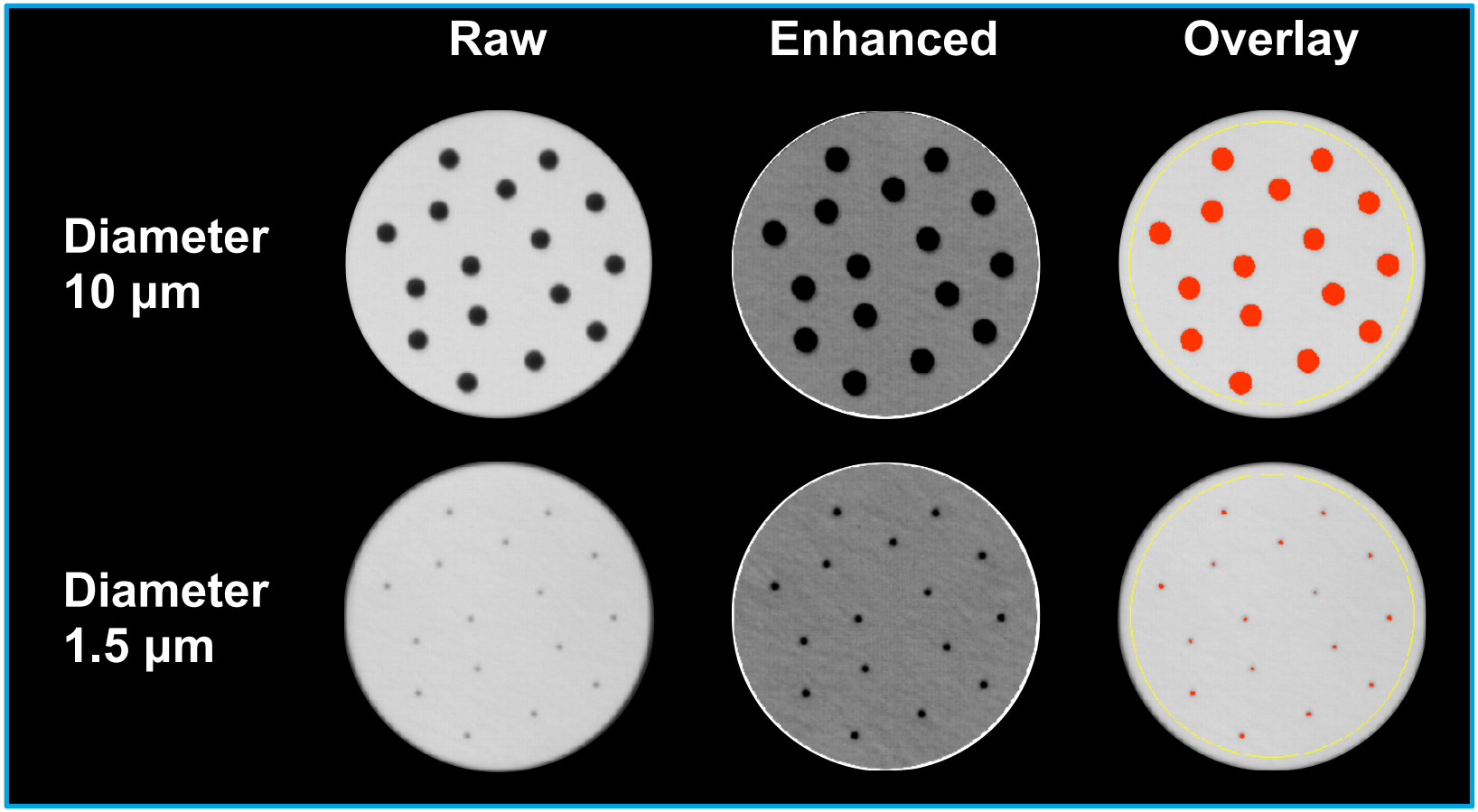
Sample Images



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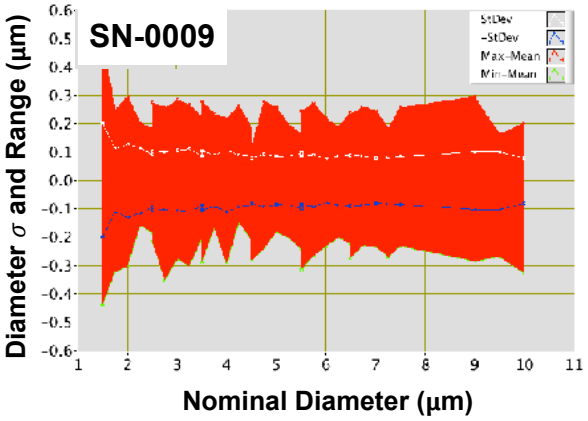
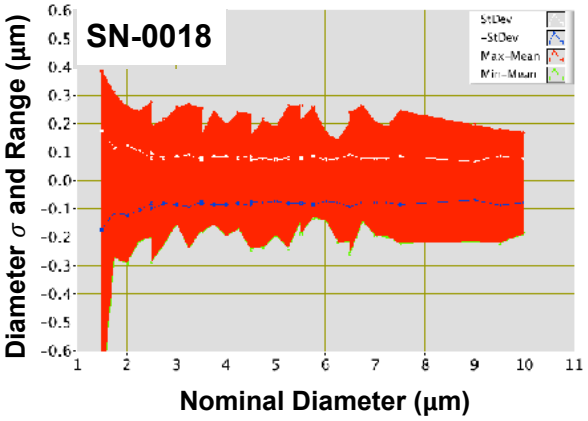
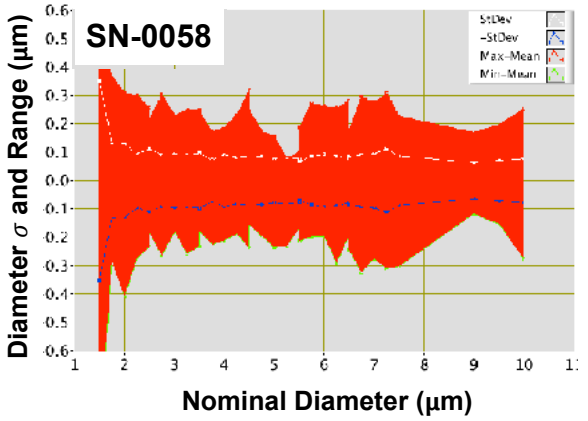
Diameter Mean and StDev vs Nominal Diameter: Target-C1







- **Mean value of diameter for each particle was computed and subtracted from repeat data.**
- **Data from particles of the same size were combined.**
- **Calculated min, max and StDev and plotted on an XY graph.**
- **These graphs show the diameter variance was independent of diameter, with exception of the smallest diameter.**

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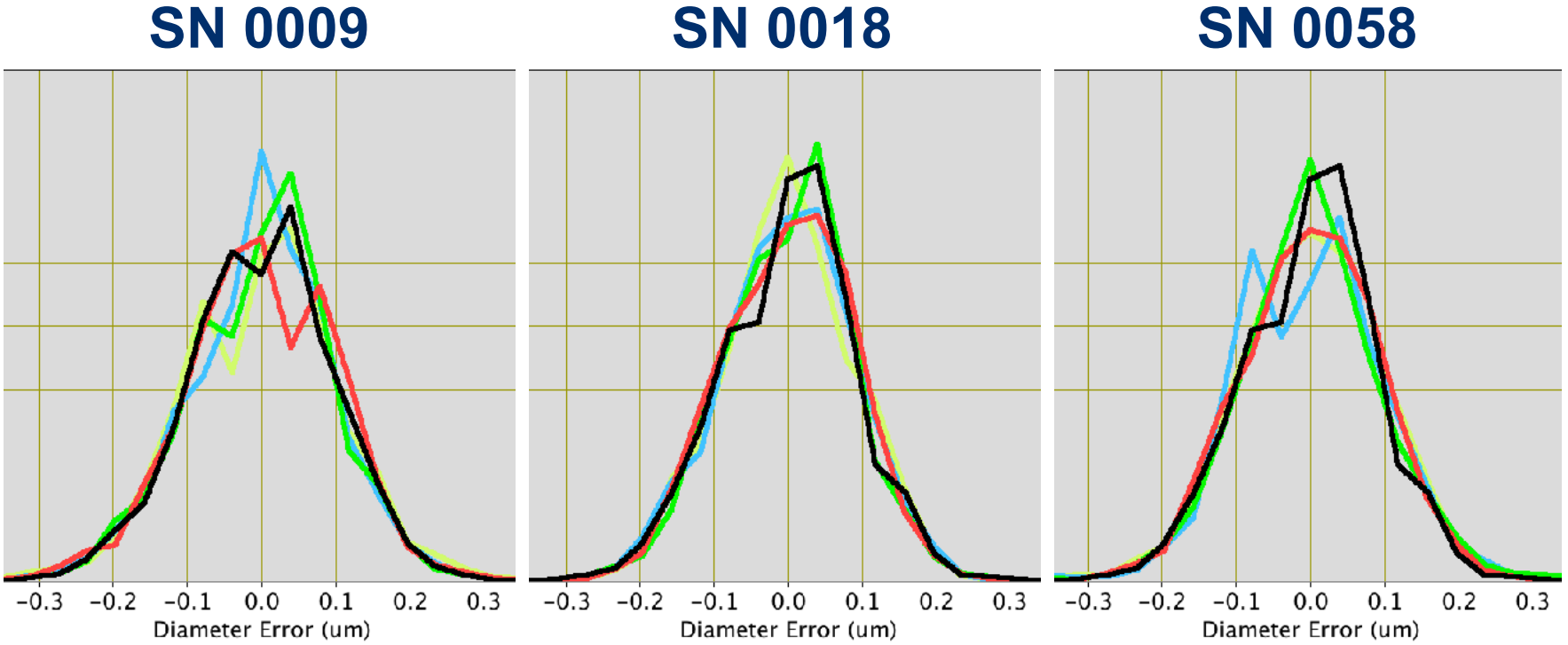
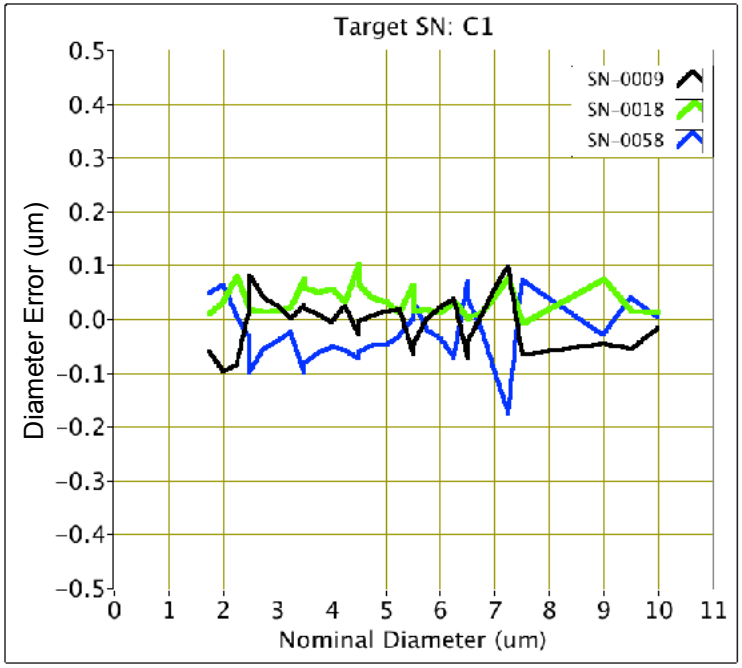
Diameter Histographs for All Targets



- **The histograph of the diameter errors for each of the five targets are plotted for each FastMT.**
- **Mean value of diameter for each particle was computed and subtracted from repeat data. Data from particles of all sizes were combined for each target to form the histogram data.**

Diameter Bias Error Computations

- **Averaged Mean Diameter across all repeats and FastMT units at each nominal diameter.**
- **Defined Diameter Error = Unit Mean Diameter- Average of All Mean Diameters.**
- **Plotted as function of nominal diameter by Test Target SN.**
- **Data for SN C1 shown, others were similar.**



Diameter Error Statistics for Target SN: C1

FastMT SN	Min	Max	Mean	StDev
0009	-0.097	0.098	-0.006	0.047
0018	-0.007	0.102	0.035	0.028
0058	-0.176	0.073	-0.029	0.056

Guard Band based on Bias and StDev

- **Bias error among units and measurement standard deviation for a given unit can be combined to estimate both systematic and random errors.**
- **A guard band of about 0.3 µm will effectively eliminate outgoing and incoming Pass/Fail discrepancies.**
- **Guard band implemented by agreeing on limit adjustments for more stringent criteria as parts move up the supply chain to final end customer delivery.**
- **From measured bias and Stdev, guard band to achieve a specific reproducibility ratio can be calculated.**

Bias	0.100 µm
Standard Deviation (σ)	0.076 µm
Bias + 3σ	0.327 µm

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Summary and Conclusions

- **Use of multiple MT-72 Test Targets, combined with the automated "Repeat" function in FastMT SW quickly produced large volume of defect diameter measurements.**
- **Three FastMT's gave very consistent results, with low bias error and low standard deviation of measured values.**
  - **Bias Error among three units was typically ±0.1 um (worst case ±0.25 um) for defects >1.75 um in diameter**
  - **Overall StDev across all units was ~ 0.075 um or <1/5th of a pixel (~0.42 um/pixel)**
- **Combining Bias and StDev yields rational approach to establishment of reproducible guard bands to achieve a desired, low rejection rate.**

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Questions?

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