

## APPLICATION NOTE

# SensoMATCH® bullet comparison software



### ► Introduction

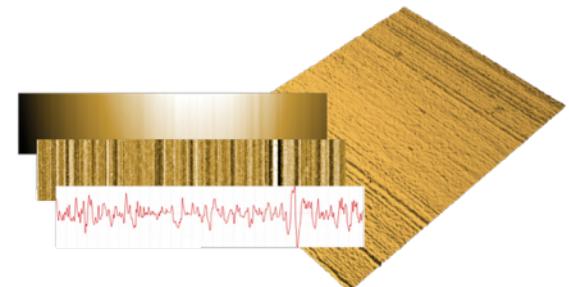
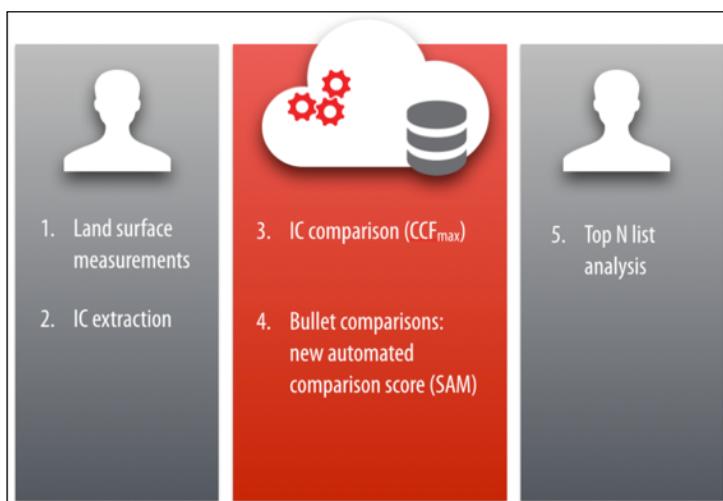
To match a bullet to a firearm, a trained examiner traditionally uses a microscope to compare the striations on each available 'land area' on the bullet to the land areas on a (known) bullet fired from the firearm. Although it has been reliable, this process is tedious and subjective.



*Land surface measurement*

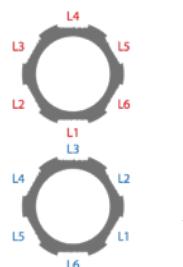
### ► Methodology

Sensofar is working to provide quantitative data on bullet lands using optical 3-dimensional metrology. **SensoMATCH®** is a new program that fully automates IC and bullet comparison. The process typically consists of five steps:



*IC surface & mean profile*

Pairs of IC surfaces are mathematically compared by extracting mean profiles from each surface and calculating a cross correlation function ( $CCF_{max}$ ). Identical profiles have a  $CCF_{max} = 1.0$ . Lower correlations yield a lower  $CCF_{max}$  value, typically 0.2 - 0.4. Higher scores thus indicate the confidence level of a match.



A single comparison of 2 bullets each with 6 lands results in 36  $CCF_{max}$  scores in a 6x6 matrix

IC	L1	L2	L3	L4	L5	L6	Seq. Av
<b>L1</b>	0.28	0.31	<b>0.88</b>	0.27	0.28	0.36	
<b>L2</b>	0.37	0.28	0.27	<b>0.88</b>	0.35	0.22	
<b>L3</b>	0.24	0.28	0.24	0.33	<b>0.89</b>	0.27	
<b>L4</b>	0.33	0.23	0.35	0.41	0.24	0.27	
<b>L5</b>	<b>0.87</b>	0.24	0.27	0.31	0.26	0.29	
<b>L6</b>	0.22	<b>0.83</b>	0.29	0.25	0.30	0.34	
<b>0.77 SAM</b>							

This comparison task scales very rapidly – comparing 15 unknown bullets to 20 known bullets results in 10,800 scores in 300 matrices.

## ► SensoMATCH® streamlines bullet comparison

To simplify analysis, we can calculate a single composite score for each bullet pair – **Sequence Average Maximum (SAM)** – that provides a clear indication of a match between bullets. The user specifies the threshold value that is used to identify matches (see graphic below right).

The entire John Hamby dataset of **15 vs. 20 bullets** (10,800 comparisons) can be processed in approximately **4 seconds**, resulting in a spreadsheet that identifies the top matches for each unknown bullet.

## ► Additional features

**SensoMATCH®** has additional features that make it an ideal tool for research in bullet comparisons based on 3D surface metrology:

- Training mode.
- **SensoMAP** template for IC comparison using customized data processing and comparison parameters.
- Missing lands compatibility.
- Comparing a set of known bullets to itself is useful for calculating statistical values for ‘Known Matches vs. Known Non-Matches’ and then using this to define **SAM** thresholds (see graphic right).
- This approach to data analysis can be made using a variety of optical metrology systems, including the Sensofar family of optical metrology systems.

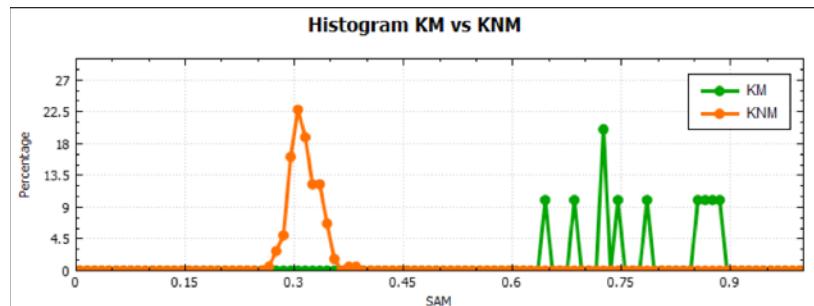
SensoMATCH results															
	B	C	D	E	F	H	J	L	M	Q	S	U	X	Y	Z
<b>1 b1</b>	0.33	<b>0.77</b>	0.32	0.32	<b>0.77</b>	0.32	0.31	0.28	0.30	0.30	0.31	0.31	0.30	0.32	0.34
<b>1 b2</b>	0.28	<b>0.73</b>	0.31	0.31	<b>0.70</b>	0.32	0.31	0.29	0.32	0.33	0.31	0.31	0.32	0.32	0.32
<b>2 b1</b>	0.29	0.33	0.30	0.31	0.31	<b>0.81</b>	0.29	0.30	0.30	0.31	0.29	0.32	0.30	0.31	0.30
<b>2 b2</b>	0.29	0.33	0.31	0.31	0.31	<b>0.81</b>	0.30	0.29	0.29	0.32	0.30	0.31	0.31	0.31	0.30
<b>3 b1</b>	0.28	0.30	0.32	0.30	0.32	0.28	0.33	0.28	0.29	0.30	<b>0.61</b>	0.29	<b>0.64</b>	0.30	0.31
<b>3 b2</b>	0.29	0.29	0.31	0.31	0.30	0.29	0.31	0.30	0.29	0.29	<b>0.61</b>	0.30	<b>0.78</b>	0.32	0.30
<b>4 b1</b>	<b>0.67</b>	0.31	0.33	0.33	0.31	0.31	0.32	0.29	0.30	0.32	0.32	0.33	0.30	0.35	0.33
<b>4 b2</b>	<b>0.61</b>	0.32	0.33	0.35	0.31	0.29	0.31	0.32	0.32	0.32	0.32	0.35	0.31	0.34	0.34
<b>5 b1</b>	0.30	0.34	<b>0.88</b>	0.37	0.34	0.29	0.33	0.30	0.35	0.33	0.32	0.31	0.29	0.34	<b>0.85</b>
<b>5 b2</b>	0.30	0.36	<b>0.88</b>	0.39	0.35	0.31	0.33	0.32	0.36	0.35	0.34	0.32	0.32	0.35	<b>0.84</b>
<b>6 b1</b>	0.27	0.31	0.32	<b>0.78</b>	0.32	0.30	0.27	0.28	<b>0.62</b>	0.28	0.28	0.28	<b>0.74</b>	0.32	0.32
<b>6 b2</b>	0.29	0.31	0.34	<b>0.74</b>	0.32	0.28	0.30	0.28	<b>0.72</b>	0.32	0.31	0.29	0.31	<b>0.68</b>	0.31
<b>7 b1</b>	0.33	0.32	0.33	0.32	0.30	<b>0.85</b>	0.30	0.29	0.31	0.36	0.30	0.31	0.32	0.33	0.33
<b>7 b2</b>	0.32	0.33	0.31	0.33	0.31	0.29	<b>0.82</b>	0.29	0.29	0.30	0.34	0.30	0.30	0.33	0.33
<b>8 b1</b>	0.31	0.32	0.31	0.31	0.29	0.33	0.29	<b>0.78</b>	0.30	0.29	0.32	0.32	0.30	0.32	0.28
<b>8 b2</b>	0.31	0.29	0.33	0.32	0.28	0.31	0.28	<b>0.79</b>	0.31	0.30	0.32	0.32	0.28	0.31	0.28
<b>9 b1</b>	0.30	0.33	0.32	0.31	0.35	0.33	0.30	0.36	0.31	0.30	0.33	<b>0.69</b>	0.32	0.32	0.33
<b>9 b2</b>	0.29	0.32	0.32	0.31	0.31	0.31	0.32	0.33	0.32	0.29	0.32	<b>0.71</b>	0.32	0.32	0.31
<b>10 b1</b>	0.30	0.28	0.32	0.34	0.28	0.30	0.28	0.26	0.31	<b>0.55</b>	0.32	0.31	0.29	0.34	0.34
<b>10 b2</b>	0.31	0.32	0.34	0.36	0.32	0.31	0.31	0.31	0.30	<b>0.60</b>	0.34	0.32	0.32	0.35	0.32

NIST results														
B	C	D	E	F	H	J	L	M	Q	S	U	X	Y	Z
<b>4</b>	<b>1</b>	<b>5</b>	<b>6</b>	<b>1</b>	<b>2</b>	<b>7</b>	<b>8</b>	<b>6</b>	<b>10</b>	<b>3</b>	<b>9</b>	<b>3</b>	<b>6</b>	<b>5</b>

John Hamby test is correctly solved

(SAM threshold 0.5)



Establishing SAM threshold  
based on the histogram of CFF<sub>max</sub> values

Sensofar is a leading-edge technology company with the highest quality standards within the field of surface metrology.

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