

**APPLICATION NOTE**

# SensoMATCH<sup>®</sup> bullet comparison software



► **Introduction**

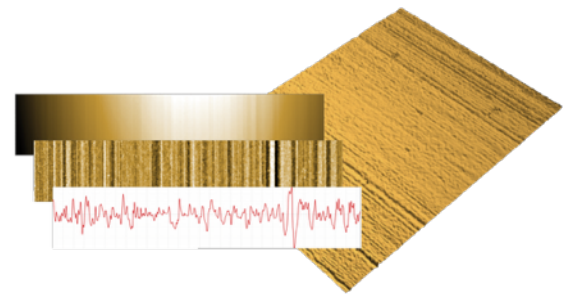
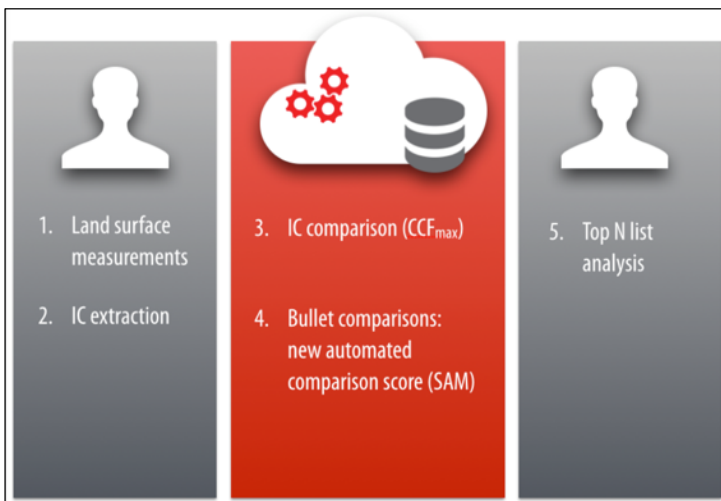
To match a bullet to a firearm, a trained examiner traditionally uses a microscope to compare the striations on each available 'land area' on the bullet to the land areas on a (known) bullet fired from the firearm. Although it has been reliable, this process is tedious and subjective.

► **Methodology**

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

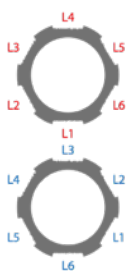


*Land surface measurement*



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

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:

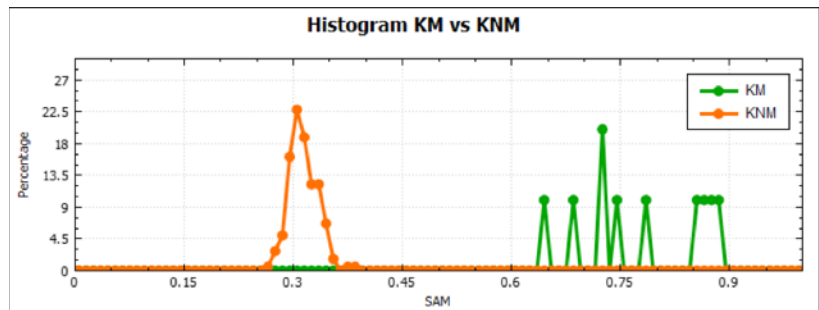
- Training mode.
- **SensoMAP** template for IC comparison using customized data processing and comparison parameters.
- Missing lands compatibility.
- Comparing a set of known bullets to itself is useful for calculating statistical values for ‘Known Matches vs. Known Non-Matches’ and then using this 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															
SAM	B	C	D	E	F	H	J	L	M	Q	S	U	X	Y	Z
1 b1	0.33	0.77	0.32	0.32	0.77	0.32	0.31	0.28	0.30	0.30	0.31	0.31	0.30	0.32	0.34
1 b2	0.28	0.73	0.31	0.31	0.70	0.32	0.31	0.29	0.32	0.33	0.31	0.31	0.32	0.32	0.32
2 b1	0.29	0.33	0.30	0.31	0.31	0.81	0.29	0.30	0.30	0.31	0.29	0.32	0.28	0.32	0.29
2 b2	0.29	0.33	0.31	0.31	0.31	0.81	0.30	0.29	0.29	0.32	0.30	0.31	0.31	0.31	0.30
3 b1	0.28	0.30	0.32	0.30	0.32	0.28	0.33	0.28	0.29	0.30	0.61	0.29	0.64	0.30	0.31
3 b2	0.29	0.29	0.31	0.31	0.30	0.29	0.31	0.30	0.29	0.29	0.61	0.30	0.78	0.32	0.30
4 b1	0.67	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
4 b2	0.61	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
5 b1	0.30	0.34	0.88	0.37	0.34	0.29	0.33	0.30	0.35	0.33	0.32	0.31	0.29	0.34	0.85
5 b2	0.30	0.36	0.88	0.39	0.35	0.31	0.33	0.32	0.36	0.35	0.34	0.32	0.32	0.35	0.84
6 b1	0.27	0.31	0.32	0.78	0.32	0.30	0.27	0.28	0.62	0.28	0.28	0.28	0.28	0.74	0.32
6 b2	0.29	0.31	0.34	0.74	0.32	0.28	0.30	0.28	0.72	0.32	0.31	0.29	0.31	0.68	0.31
7 b1	0.33	0.32	0.33	0.32	0.30	0.32	0.85	0.30	0.29	0.31	0.36	0.30	0.31	0.32	0.33
7 b2	0.32	0.33	0.31	0.33	0.31	0.29	0.82	0.29	0.29	0.30	0.34	0.30	0.30	0.33	0.33
8 b1	0.31	0.32	0.31	0.31	0.29	0.33	0.29	0.78	0.30	0.29	0.32	0.32	0.30	0.32	0.28
8 b2	0.31	0.29	0.33	0.32	0.28	0.31	0.28	0.79	0.31	0.30	0.32	0.32	0.28	0.31	0.28
9 b1	0.30	0.33	0.32	0.31	0.35	0.33	0.30	0.36	0.31	0.30	0.33	0.69	0.32	0.32	0.33
9 b2	0.29	0.32	0.32	0.31	0.31	0.31	0.32	0.33	0.32	0.29	0.32	0.71	0.32	0.32	0.31
10 b1	0.30	0.28	0.32	0.34	0.28	0.30	0.28	0.26	0.31	0.55	0.32	0.31	0.29	0.34	0.34
10 b2	0.31	0.32	0.34	0.36	0.32	0.31	0.31	0.31	0.30	0.60	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	
4	1	5	6	1	2	7	8	6	10	3	9	3	6	5	

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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