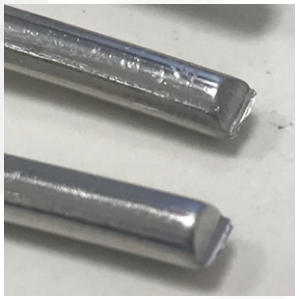
SENSOFAR®
METROLOGY



3D EDUCATIONAL DAY

3TH ANNUAL MEETING OF 3D2TWG
6TH NOVEMBER 2019
FBI ACADEMY

AGENDA

- The company
- S neox Forensics
- Measurement principles
- Firearms & toolmarks
- VCM
- Objective identification
- Critical dimensions
- Future

Adam Platteis
US Sales Manager

Cristina cadevall
PhD in Optics
VP Software

THE COMPANY

THE COMPANY

Headquarters & Sales Offices

Sensofar METROLOGY
Barcelona (SPAIN)
1600 m^2 production
and R+D facilities

Sensofar ASIA
Shanghai (CH)
Taipei (TW)

Sensofar GERMANY
Munich (GE)

Sensofar USA
Newington (US)

THE COMPANY

Global network

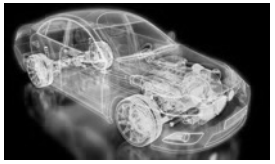
SENSOFAR. METROLOGY

THE COMPANY

Sensofar Team

THE COMPANY

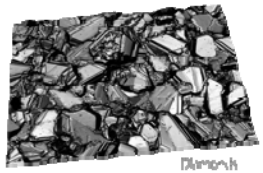
Applications



Automotive

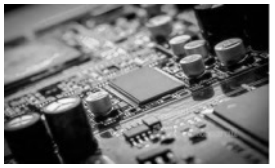
Energy

LASER Processing

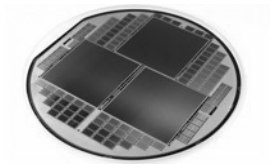


Diamonds

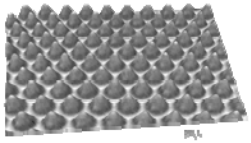
Leather



Microelectronics



Semiconductors



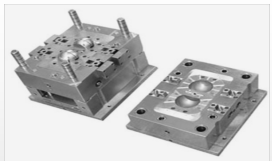
PSS

Micro manufacturing

Medical & Pharma

Tool Industry

Aerospace



Injection molding

Forensics

THE COMPANY

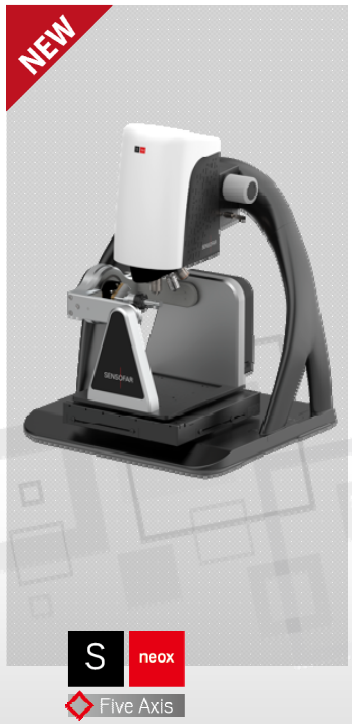
SENSOFAR METROLOGY

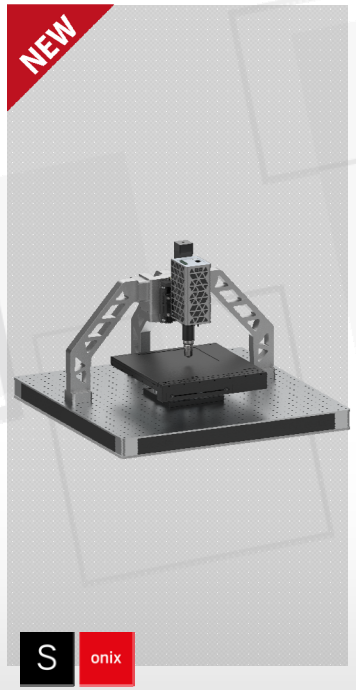
Customer references

THE COMPANY

Systems & Sensors

SENSOFAR METROLOGY

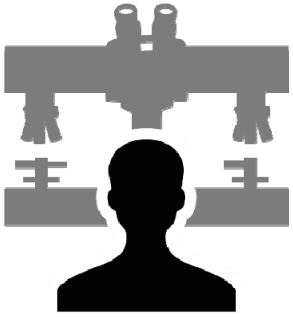




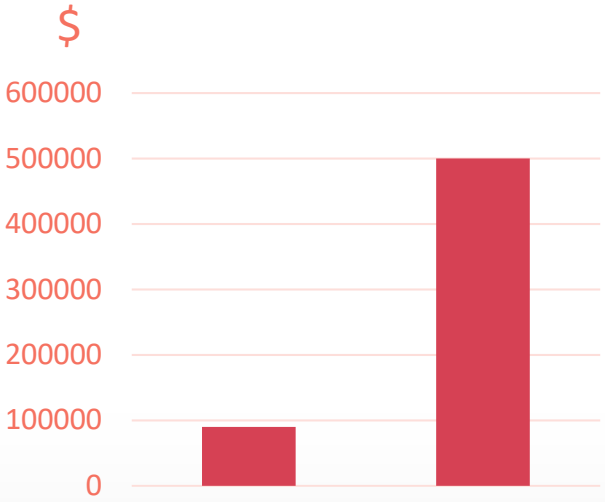
3DED 2019

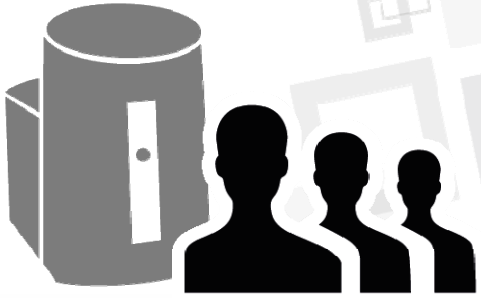
S NEOX FORENSICS

S NEOX FORENSICS



Comparison microscope

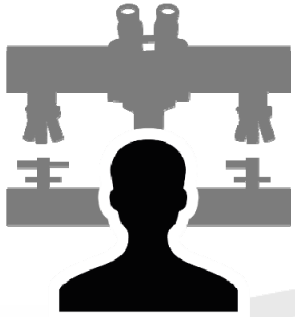




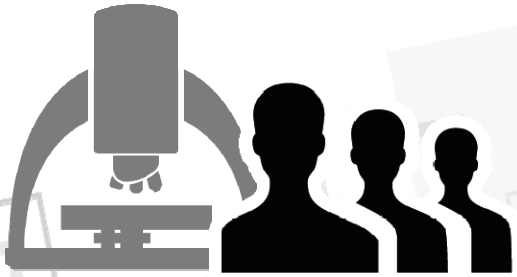
Automatic Ballistic Identification Systems (ABIS)

S NEOX FORENSICS

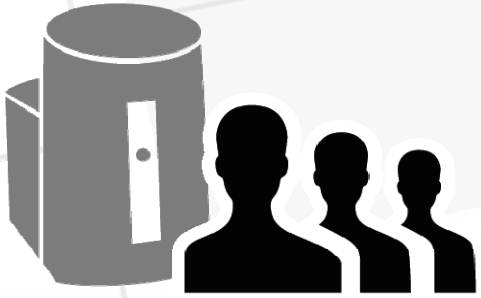
SENSOFAR. METROLOGY



Comparison microscope

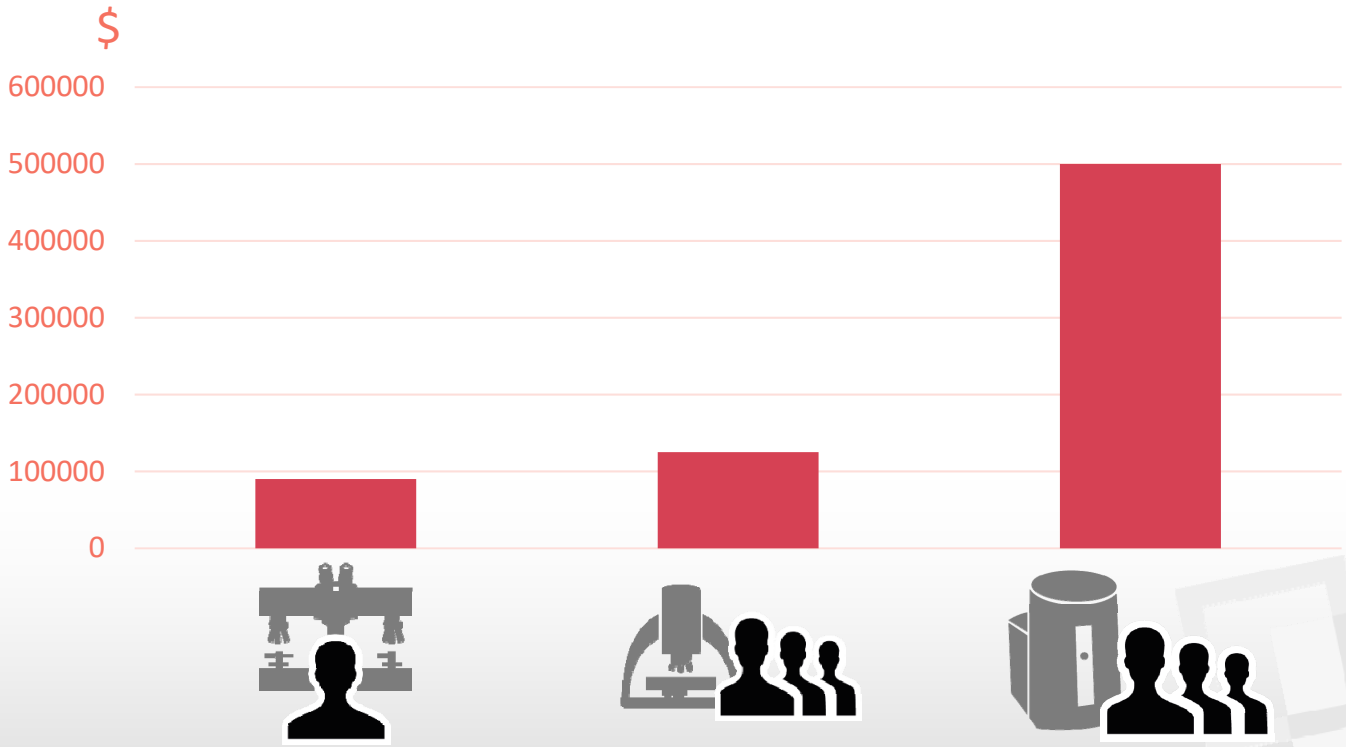


3D optical profiler



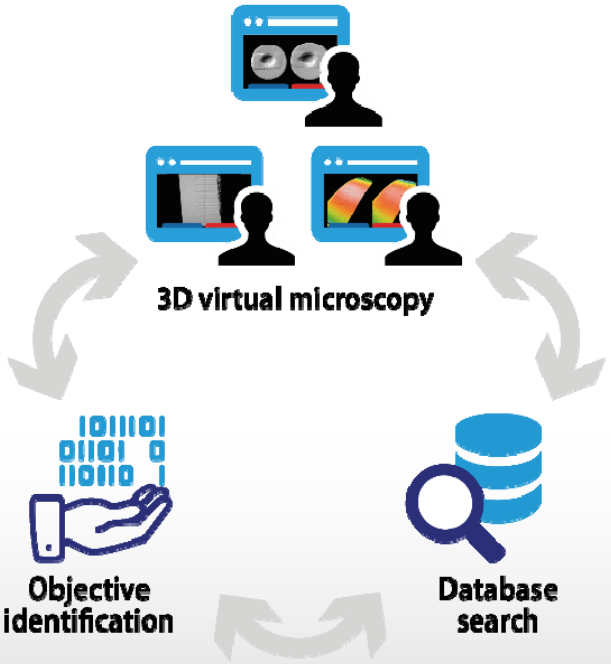
Automatic Ballistic Identification Systems (ABIS)

S NEOX FORENSICS



S NEOX FORENSICS

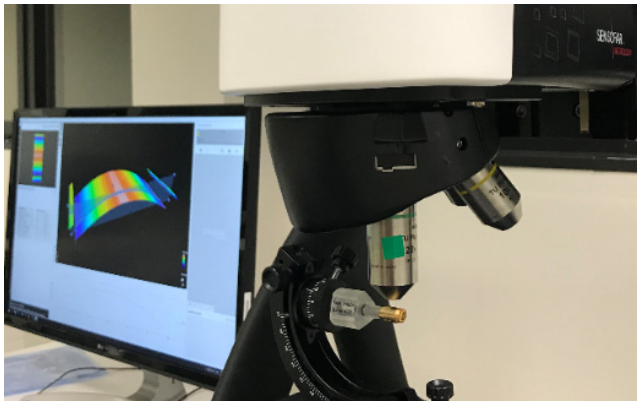
SENSOFAR. METROLOGY



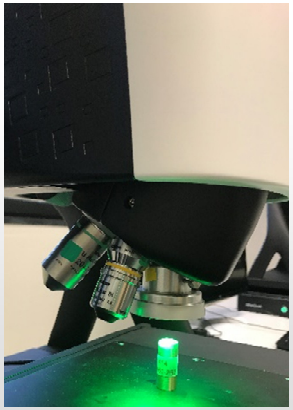
3DED 2019

S NEOX FORENSICS

Hardware options



Manual holder options



SENSOFAR METROLOGY

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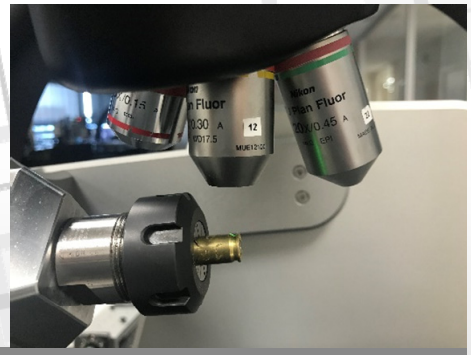
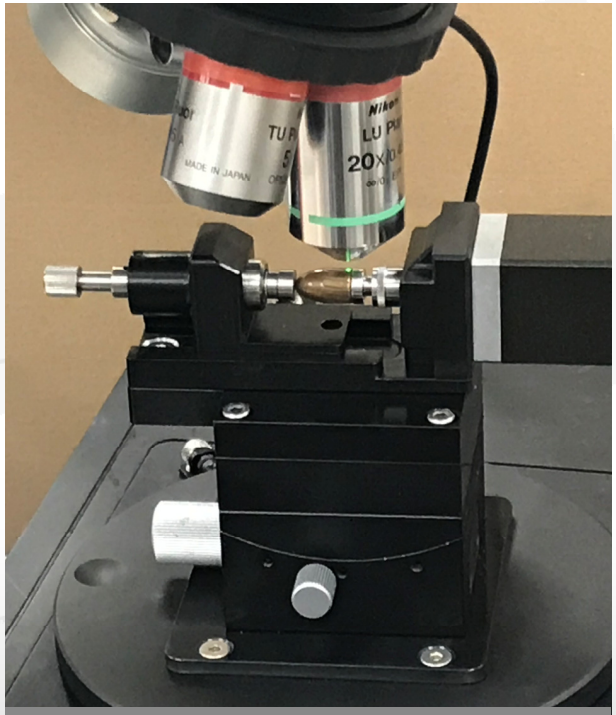
S NEOX FORENSICS

Hardware options



Five axis option



Four axis option

S NEOX FORENSICS

Hardware options

Standard | High | Wide | High & Wide

S NEOX FORENSICS

Software

SENSOFAR. METROLOGY

ACQUISITION

SensoSCAN 7

option

SensoFIVE 7

ANALYSIS

SensoCOMP

SensoVIEW

option

SensoMAP

AUTOMATION & ANALYSIS

option

SensoMATCH

option

SensoPRO 3

SDK

option

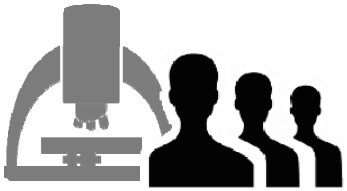
SDK

3DED 2019

S NEOX FORENSICS

Open system

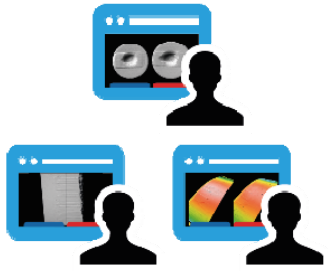
SENSOFAR. METROLOGY



Network

Local
Agency
State
National
International

X3P
OpenFMC



3D virtual microscopy

Objective identification

Database search

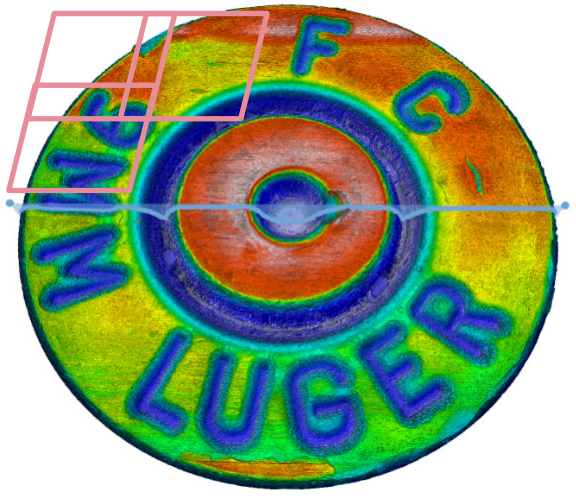
S NEOX FORENSICS

Automation

SENSOFAR. METROLOGY

Automated procedures module (APM)

Extended measurement module (EMM)

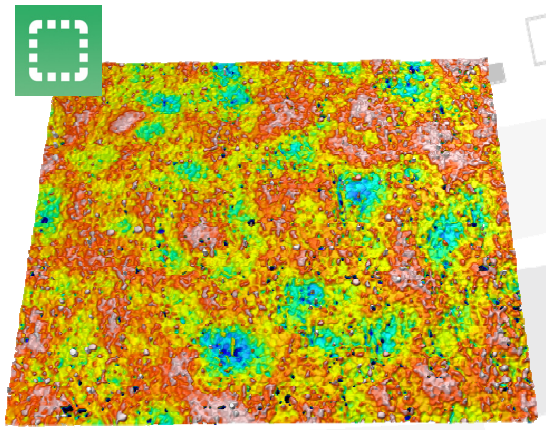


MEASUREMENT PRINCIPLES

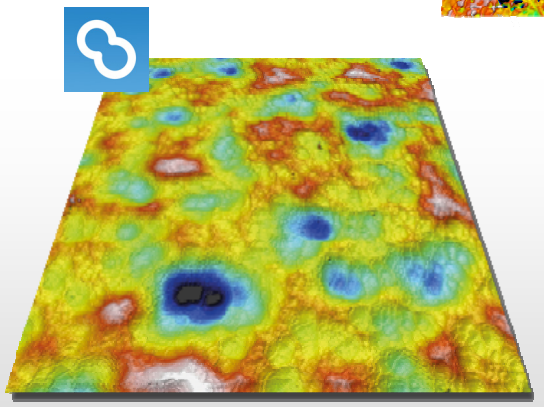
MEASUREMENT PRINCIPLES

Performance comparison

	FOCUS VARIATION	CONFOCAL	INTERFEROMETRY
Rough samples	★★★	★★★	★
Smooth samples		★★	★★★
Micro-scale features	★★	★★★	★★★
Nano-scale features		★★	★★★
High local slopes	★★★	★★	★
Thickness		★★★	★★★



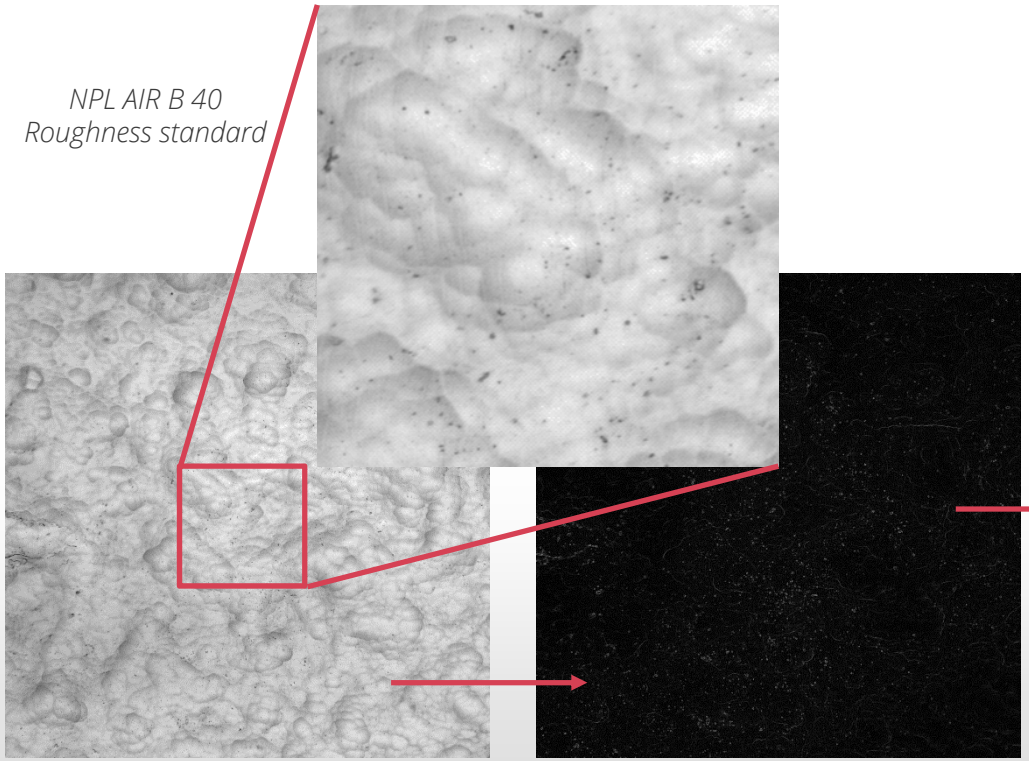
NPL AIR B 40
Roughness standard

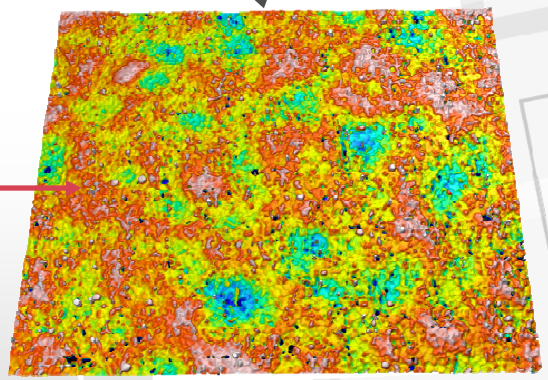


MEASUREMENT PRINCIPLES

Focus Variation

SENSOFAR. METROLOGY

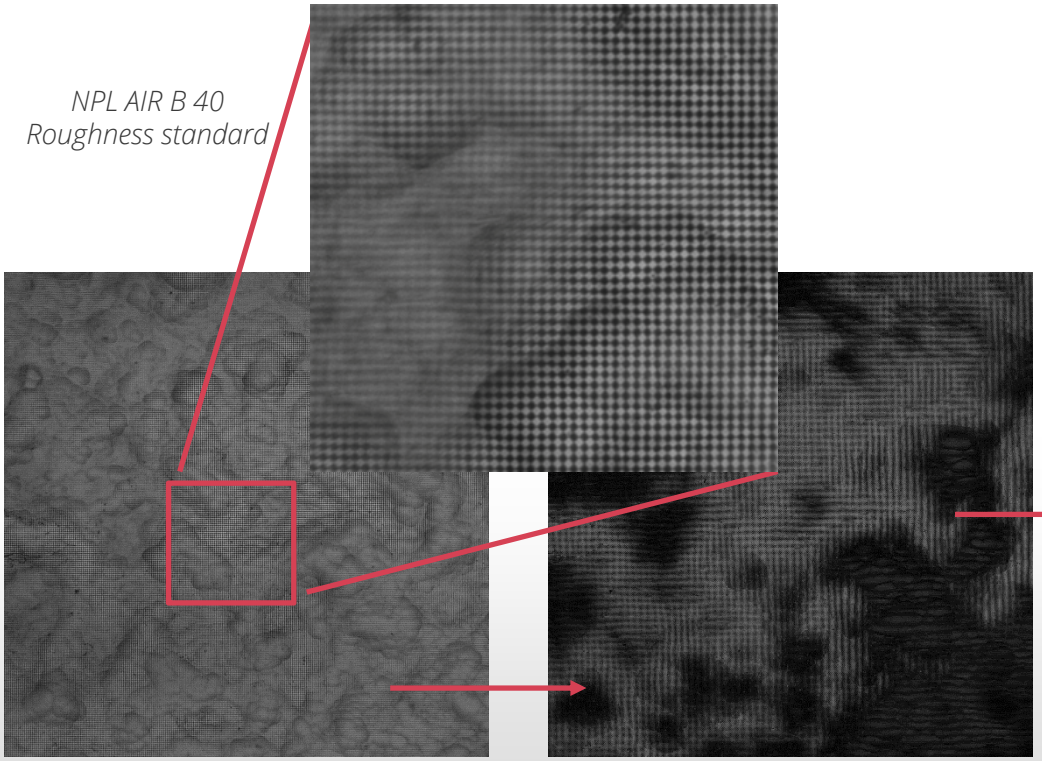




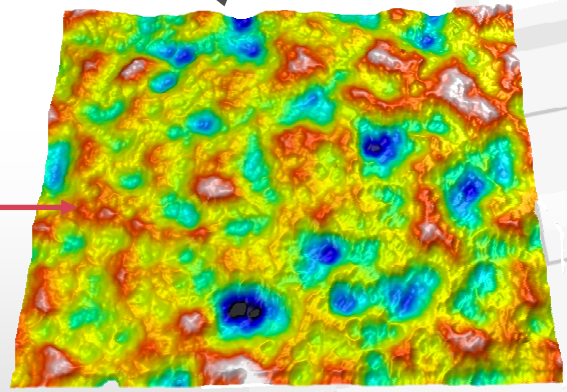
MEASUREMENT PRINCIPLES

Active Illumination Focus Variation

SENSOFAR. METROLOGY



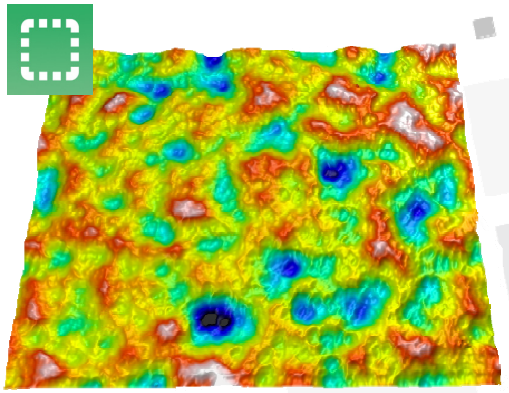
Active Ilumination Focus Variation on smooth surface



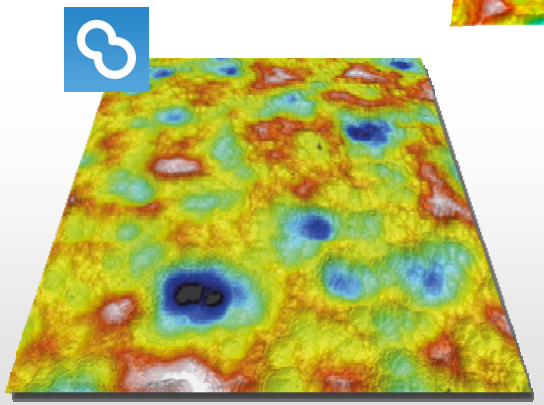
MEASUREMENT PRINCIPLES

Performance comparison

	Ai FOCUS VARIATION	CONFOCAL	INTERFEROMETRY
Rough samples	★★★	★★★	★
Smooth samples	★	★★	★★★
Micro-scale features	★★	★★★	★★★
Nano-scale features		★★	★★★
High local slopes	★★★	★★	★
Thickness		★★★	★★★



NPL AIR B 40
Roughness standard

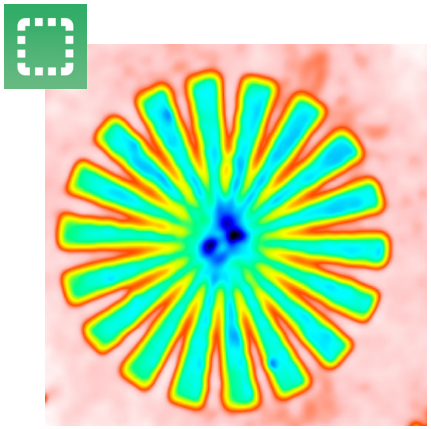


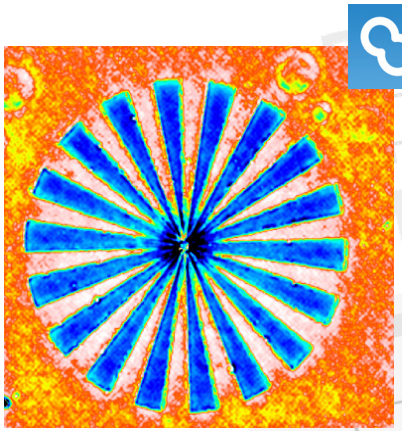
MEASUREMENT PRINCIPLES

Performance comparison

SENSOFAR. METROLOGY

	Ai FOCUS VARIATION	CONFOCAL	INTERFEROMETRY
Rough samples	★★★	★★★	★
Smooth samples	★	★★	★★★
Micro-scale features	★★	★★★	★★★
Nano-scale features		★★	★★★
High local slopes	★★★	★★	★
Thickness		★★★	★★★



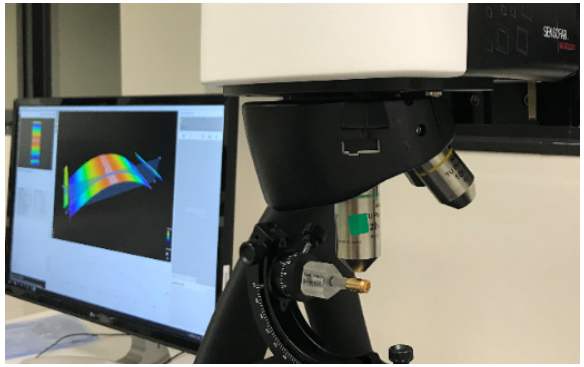


Siemens Star from NPL Bento Box, model ASP-02 P18
20X 0.45 NA 0.46 µm center wavelength

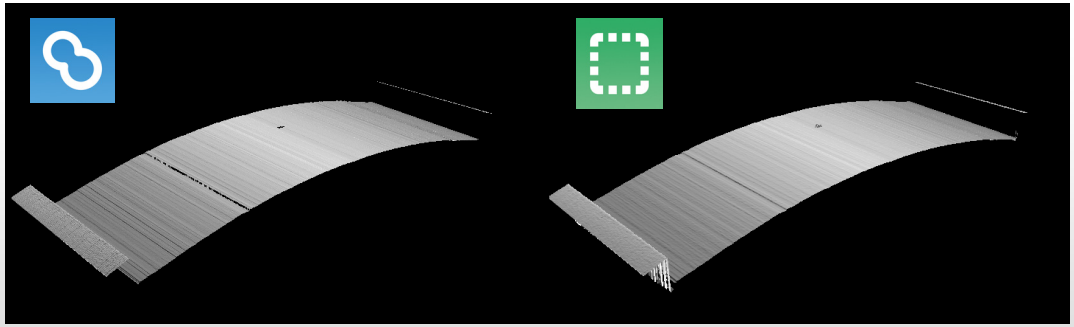
Active illumination focus variation
Carlos Bermudez, Pol Martinez, Cristina Cadevall, Roger Artigas
Proc. SPIE. 11056, Optical Measurement Systems for Industrial Inspection XI

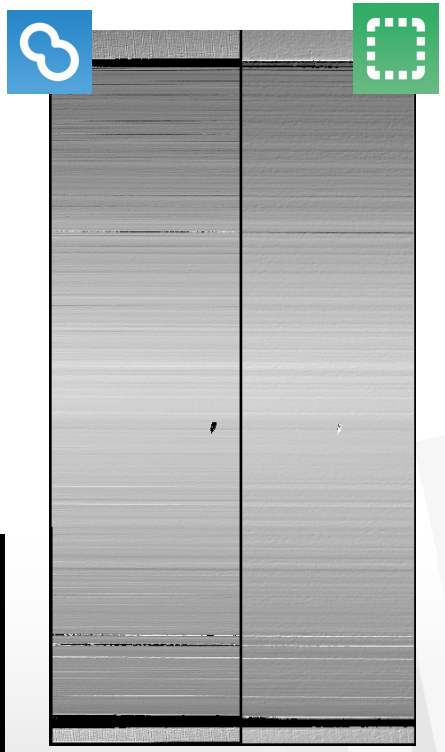
MEASUREMENT PRINCIPLES

Bullets



NIST Standard Reference Material 2460a Land 1

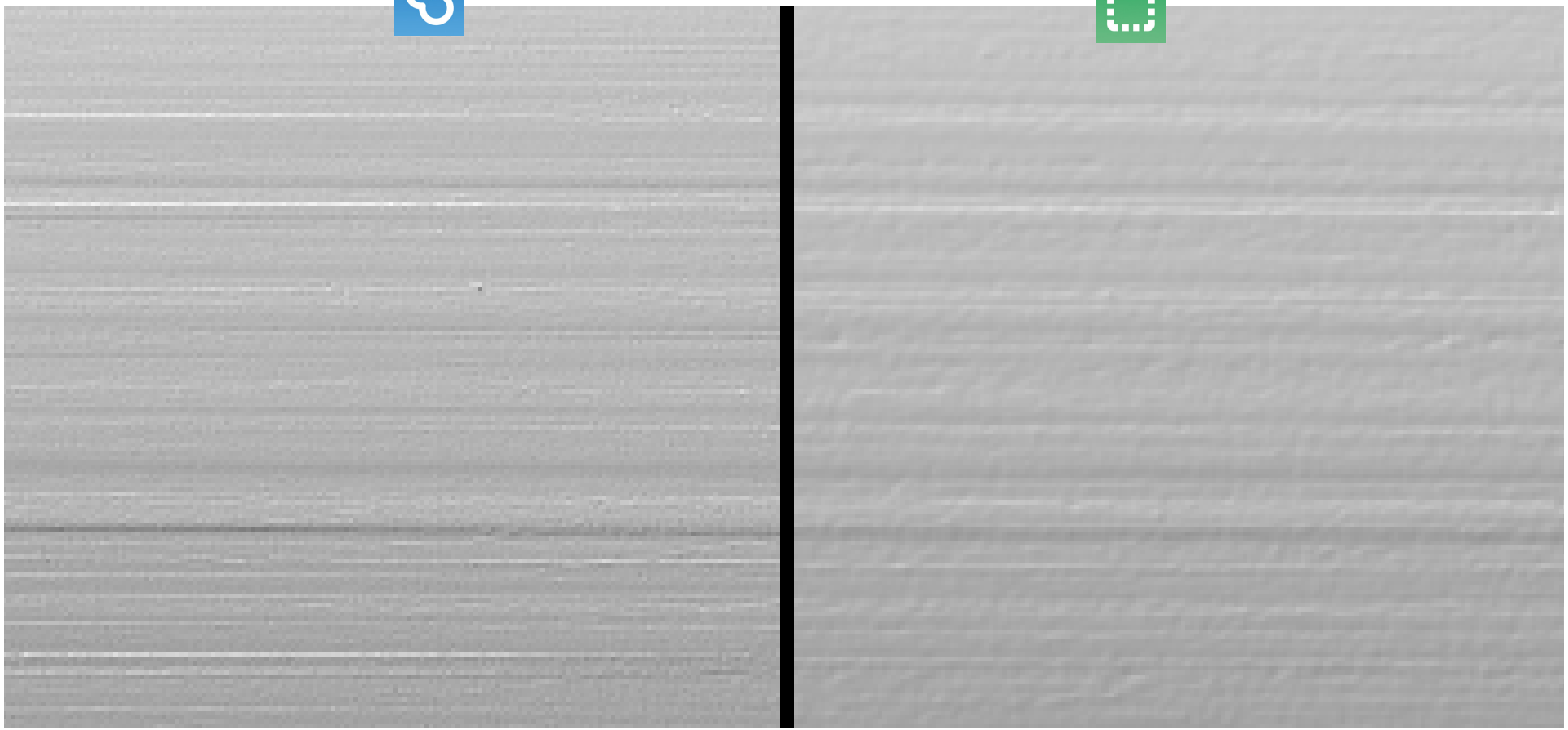




MEASUREMENT PRINCIPLES

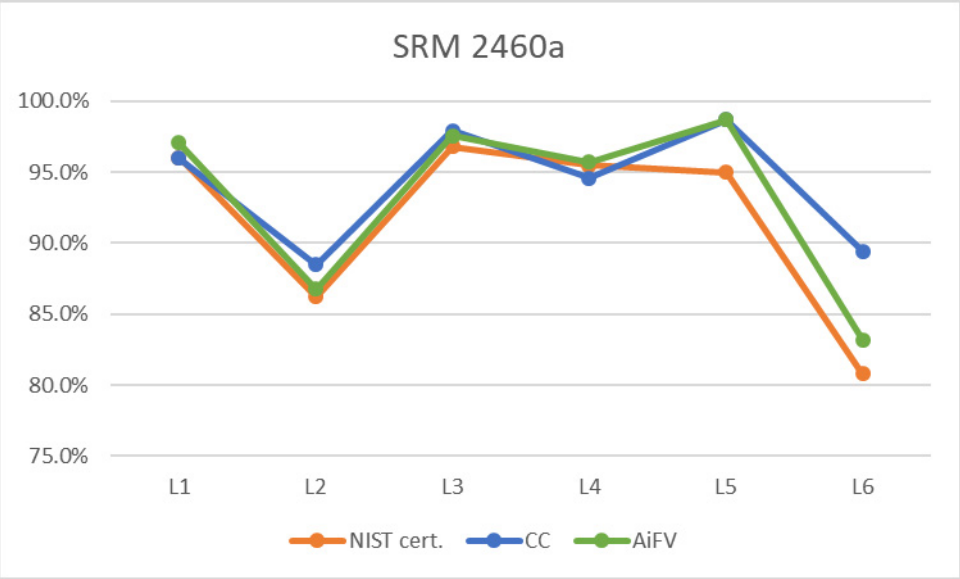
SENSOFAR. METROLOGY

Bullets



MEASUREMENT PRINCIPLES

Bullets



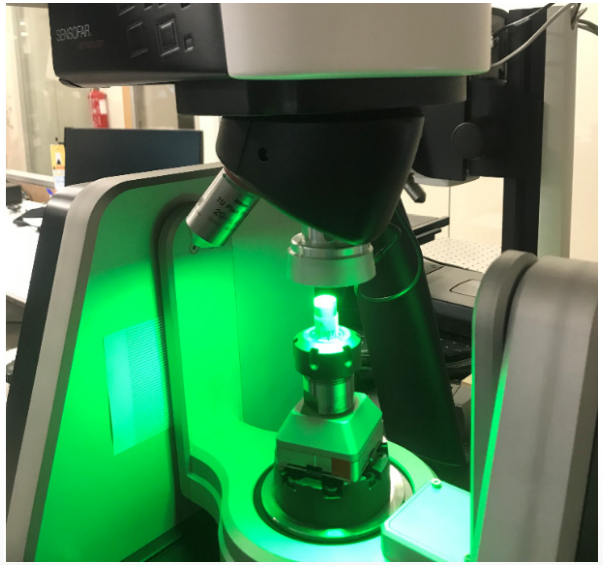
NIST Standard Reference Material 2460a lands

20X EPI objective

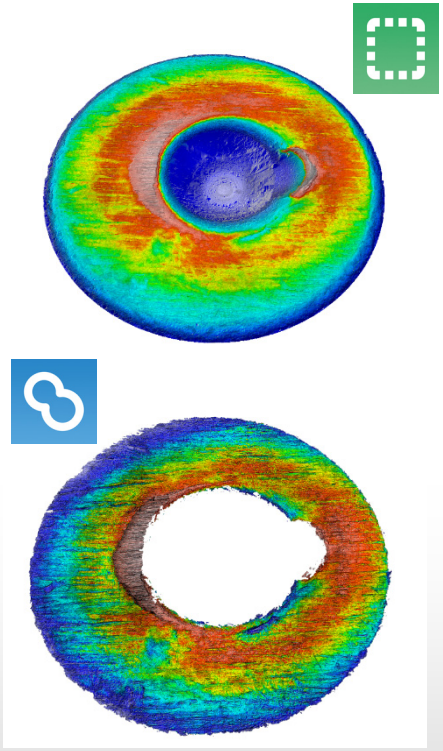
0.45 NA, pixel size 0.69 μm

MEASUREMENT PRINCIPLES

Cartridge cases



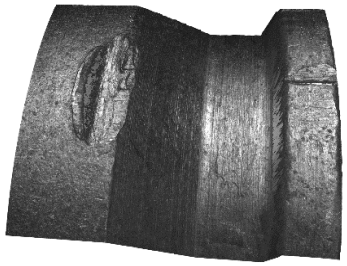
NIST Standard Reference Material 2461



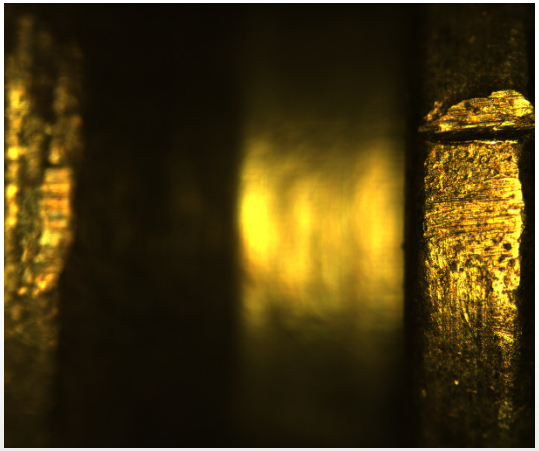
FIREARMS & TOOLMARKS

FIREARMS & TOOLMARKS

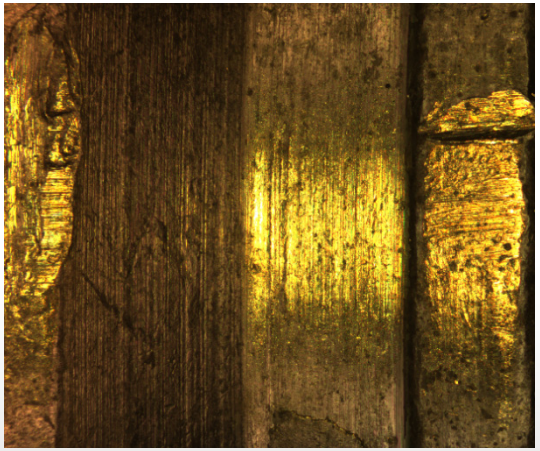
2D images



Extractor mark surface WVU CA
10X EPI
3D + Stack image



5X EPI color image



5X EPI all-in-focus color

5X EPI all-in-focus reflectivity

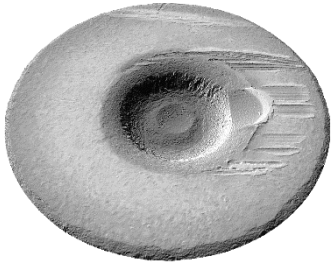
FIREARMS & TOOLMARKS

3D topographies

SENSOFAR. METROLOGY

Cartridges provided by Eric Law
West Virginia University

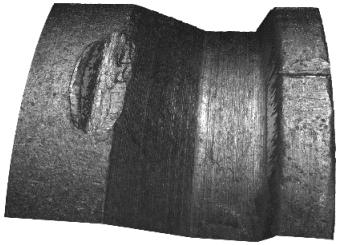
Top cartridge case surface WVU CA
5X EPI / 3D + color image



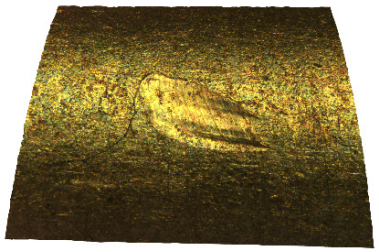
Breech face surface WVU CB
10X EPI / 3D + directional rendering

Ejector mark SRM2461
20X EPI / 3D + stack image

25 s
to
8 min 30 s



Extractor mark surface WVU CA
10X EPI / 3D + stack image



Chamber mark surface WVU CA
5X EPI / 3D + color image

FIREARMS & TOOLMARKS

LEA 3D topographies

SENSOFAR. METROLOGY

Bullets provided by Tylor Klep
Phoenix Police Department

6 min

Land surfaces
20X EPI / 3D + directional rendering

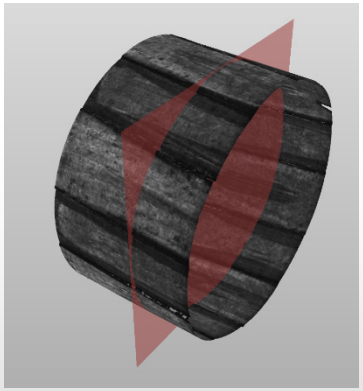
3DED 2019

FIREARMS & TOOLMARKS

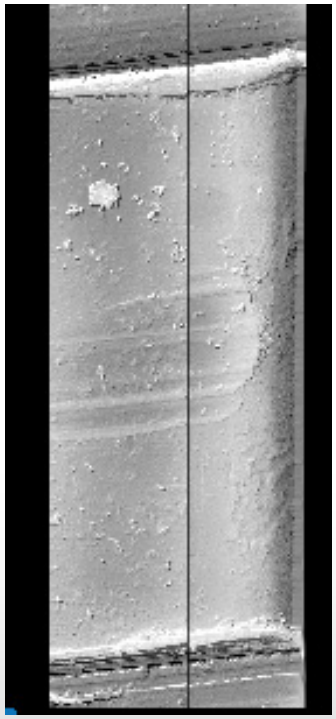
Full 3D and unrolled topographies

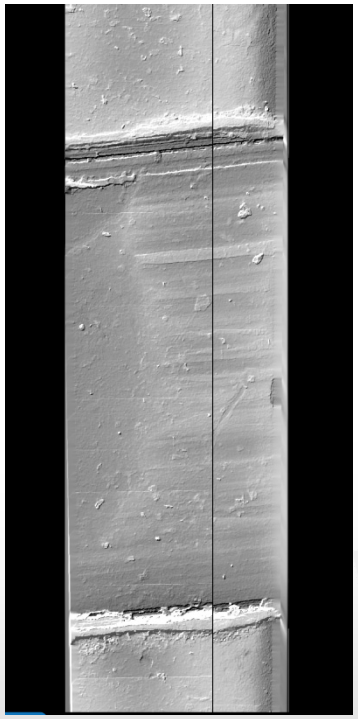
SENSOFAR. METROLOGY

Bullets provided by Tylor Klep
Phoenix Police Department



15 min





Comparison of groove and land surfaces
20X EPI / Contour + directional rend

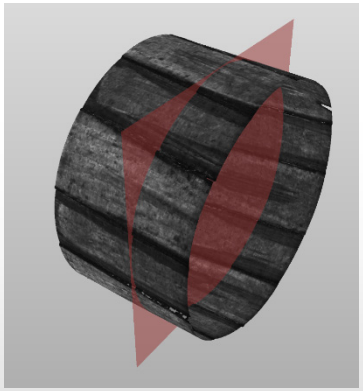
FIREARMS & TOOLMARKS

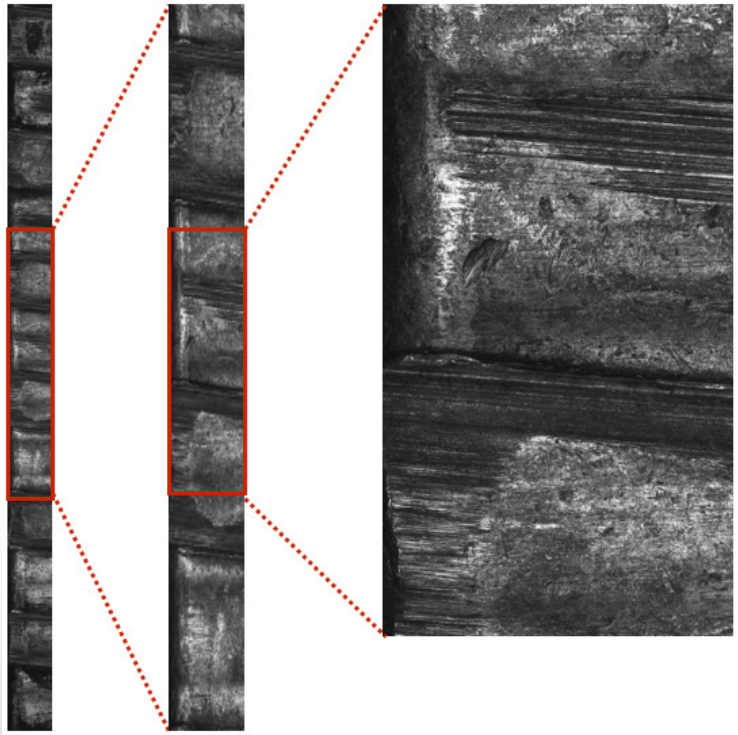
Full 3D and unrolled reflectivity images

SENSOFAR. METROLOGY

Bullets provided by Tylor Klep
Phoenix Police Department

15 min





Groove and land details
20X EPI / Reflectivity image

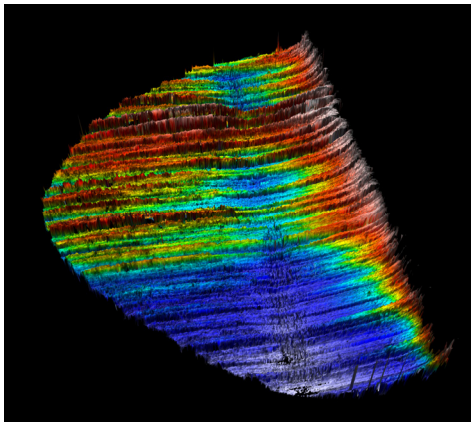
FIREARMS & TOOLMARKS

3D topographies

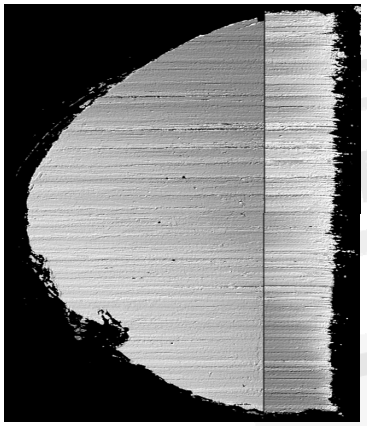
SENSOFAR. METROLOGY

Cables provided by Jean-Alexandre Patteet
École des Sciences criminelles (UNIL)

1 min



Cable surface
20X EPI / 3D + false color rendering

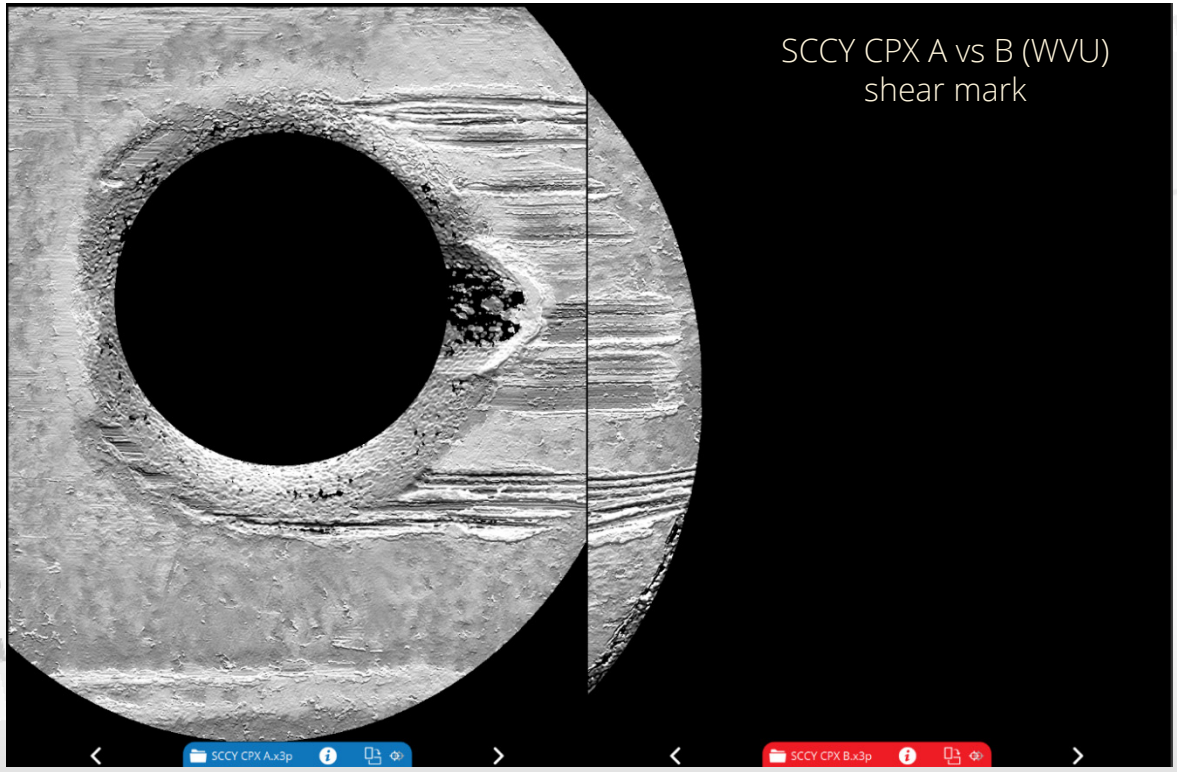


Cable surfaces comparison
20X EPI / Contour + directional rendering

VCM

VCM

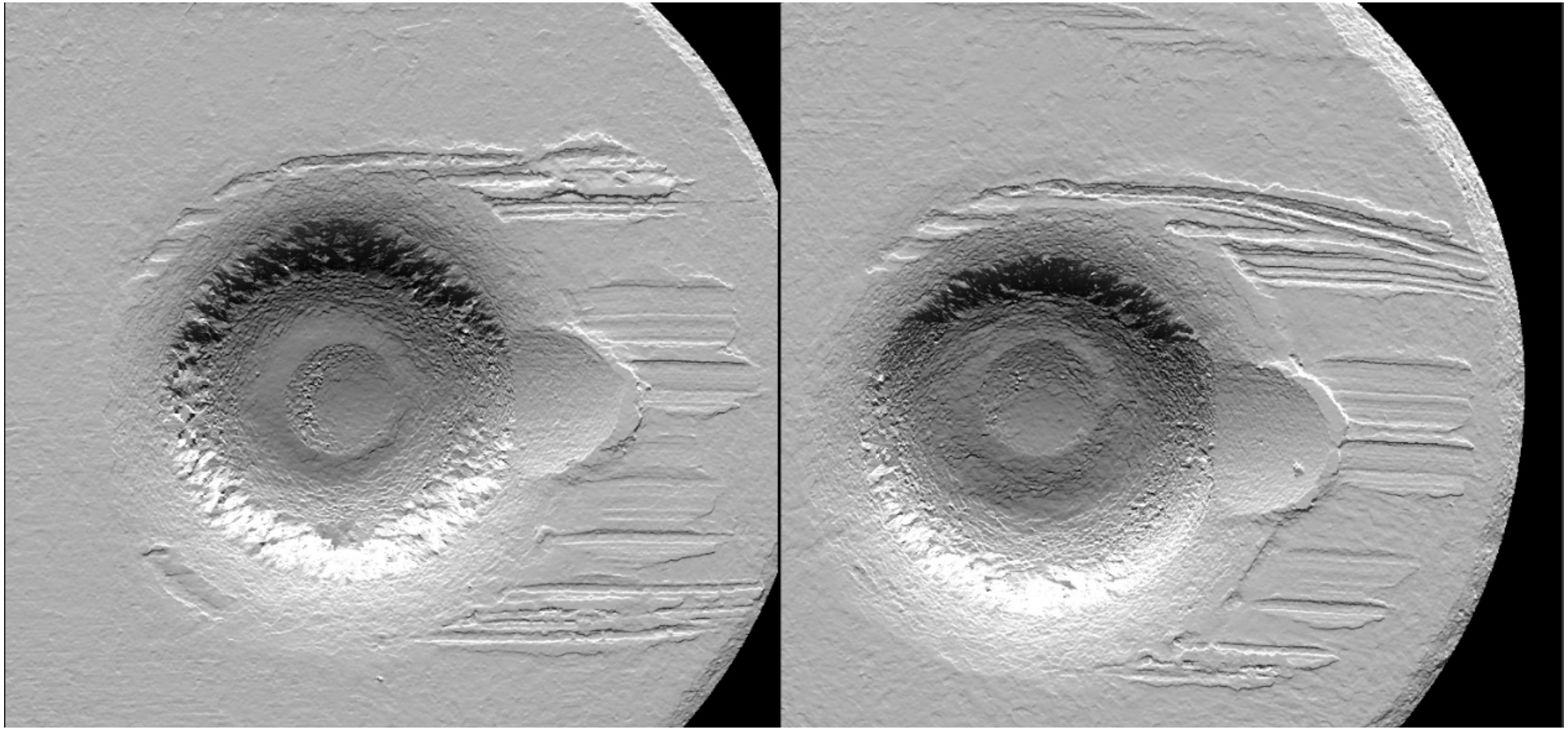
Analysis capabilities



VCM

Analysis capabilities

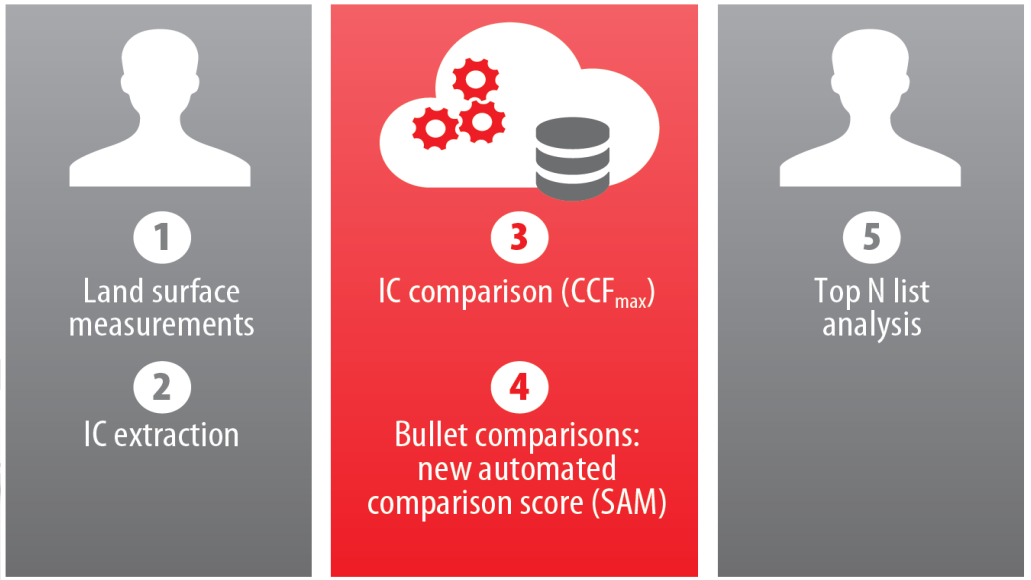
SENSOFAR. METROLOGY



OBJECTIVE IDENTIFICATION

OBJECTIVE IDENTIFICATION

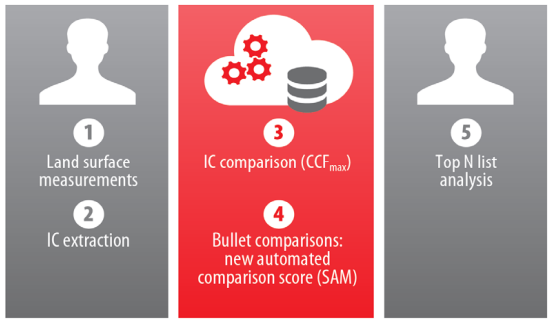
Bullets

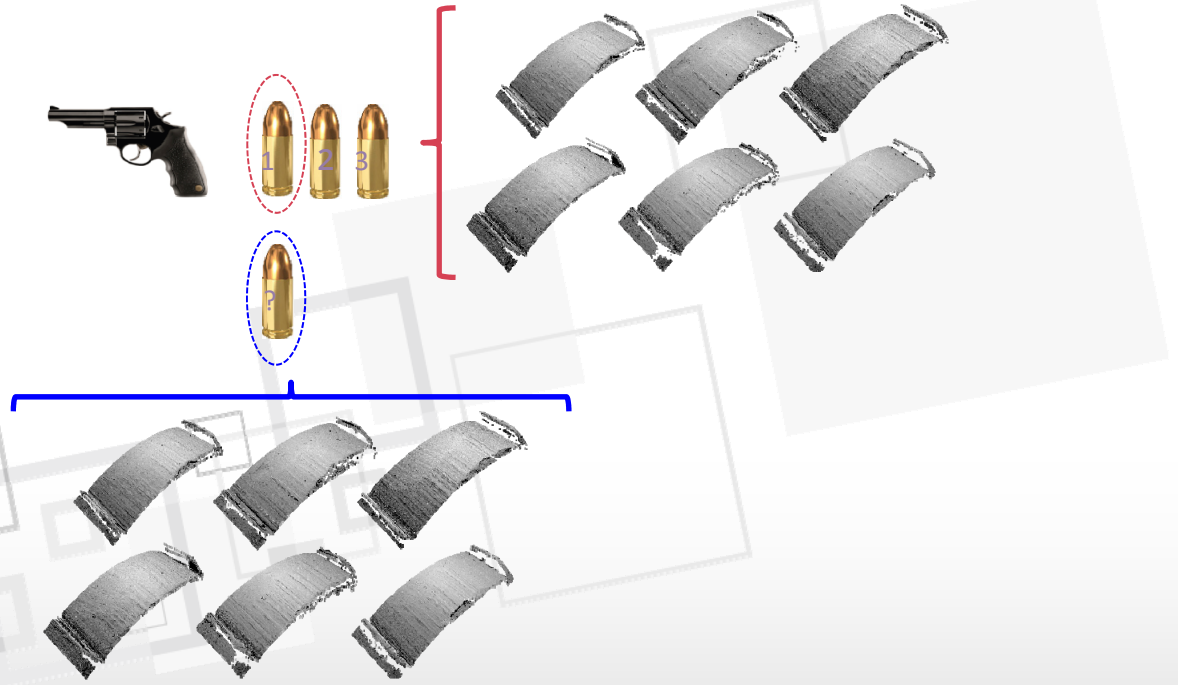


OBJECTIVE IDENTIFICATION

Bullets

SENSOFAR. METROLOGY





OBJECTIVE IDENTIFICATION

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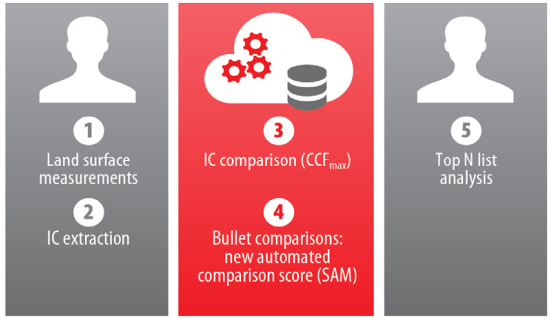
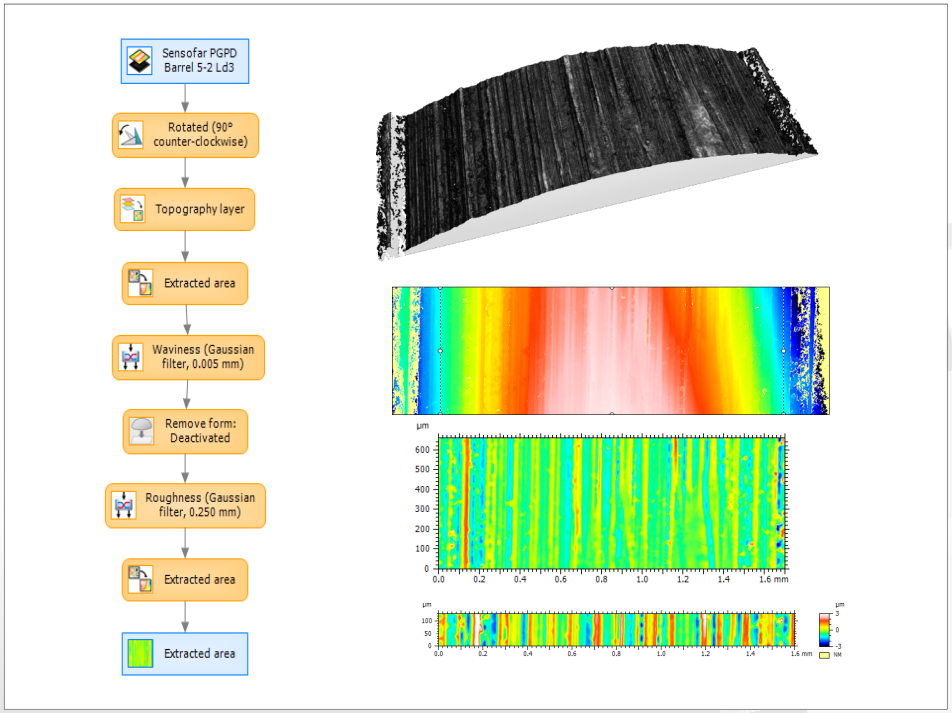
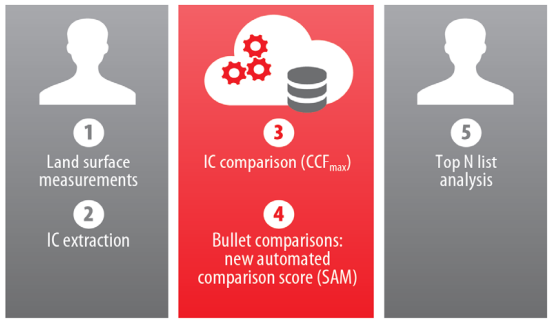


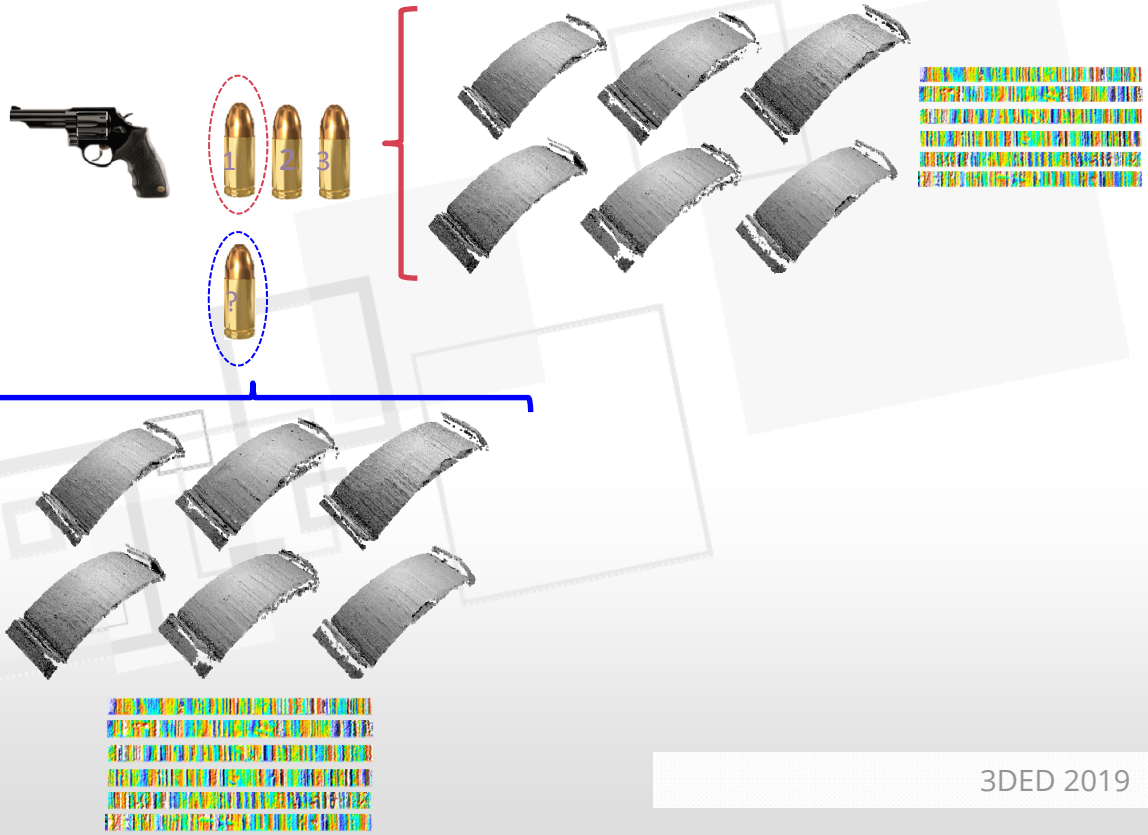


OBJECTIVE IDENTIFICATION

Bullets

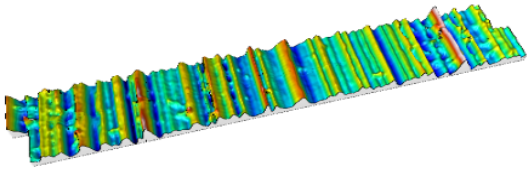
SENSOFAR. METROLOGY

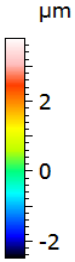


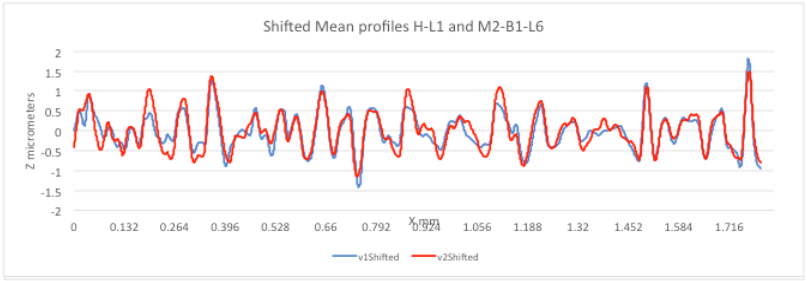


OBJECTIVE IDENTIFICATION

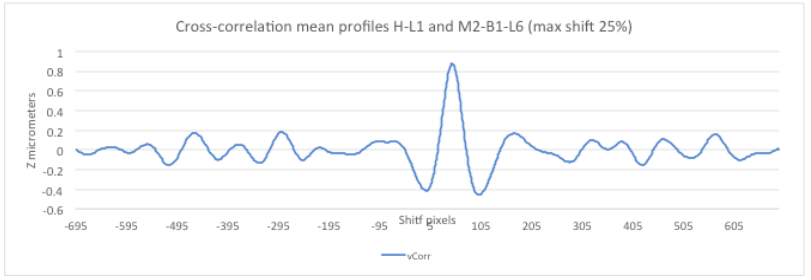
Bullets







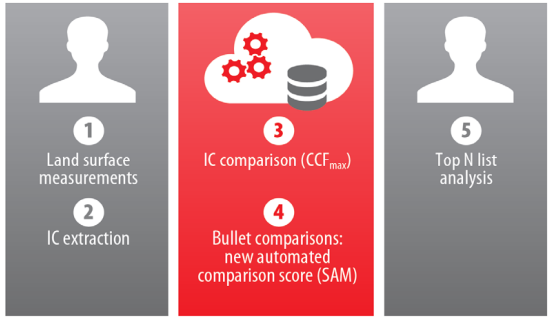
$$(f * g)[i] \equiv \frac{1}{N-1} \sum_{l=0}^{N-1} \frac{(f[l] - \bar{f}) \cdot (g[l+i] - \bar{g})}{\sigma_f \cdot \sigma_g}$$

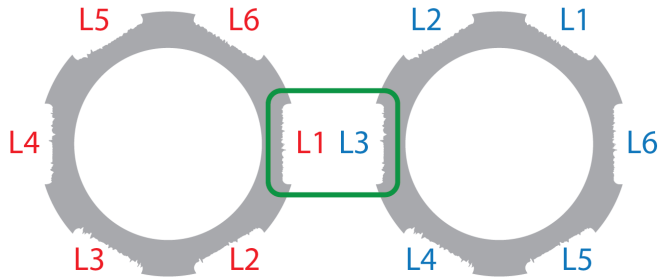


$CCF_{max}=0.91$

OBJECTIVE IDENTIFICATION

Bullets

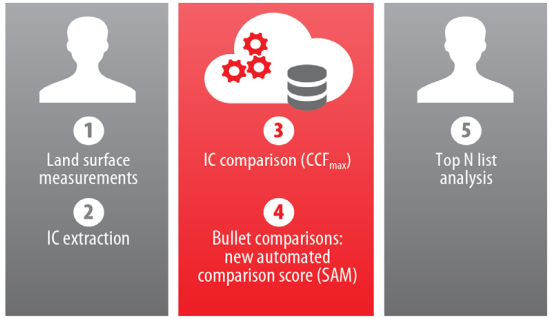




IC	L1	L2	L3	L4	L5	L6	Seq. Av
L1	0.28	0.31	**0.88**	0.27	0.28	0.36	0.30
L2	0.37	0.28	0.27	**0.88**	0.35	0.22	0.28
L3	0.24	0.28	0.24	0.33	**0.89**	0.27	**0.77** SAM
L4	0.33	0.23	0.35	0.41	0.24	0.27	0.29
L5	**0.87**	0.24	0.27	0.31	0.26	0.29	0.25
L6	0.22	**0.83**	0.29	0.25	0.30	0.34	0.33

OBJECTIVE IDENTIFICATION

Bullets



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

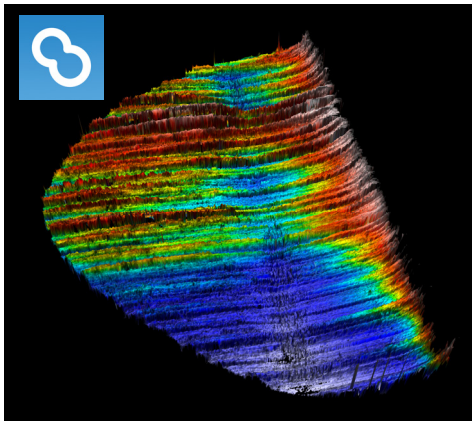
B	C	D	E	F	H	J	L	M	Q	S	U	X	Y	Z
4	1	5	6	1	2	7	8	6	10	3	9	3	6	5

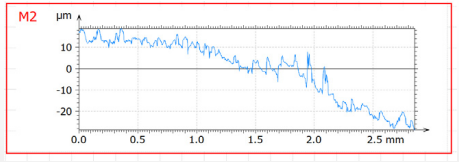
John Hamby test correctly solved
SAM threshold = 0.5

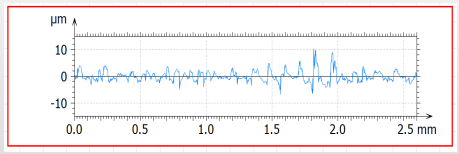
OBJECTIVE IDENTIFICATION

Cables

Cables provided by Jean-Alexandre Patteet
École des Sciences criminelles (UNIL)







Surface Rotation 0º

	M1	M3
M2	0.289	**0.917**
M3	0.254	

Surface Rotation 180º

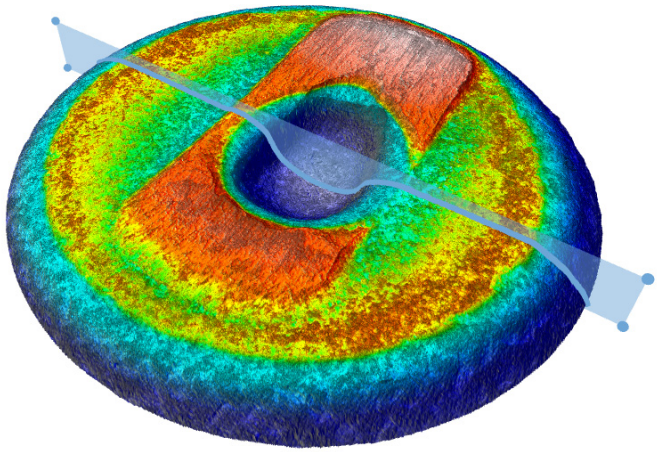
	M1	M3
M2	0.363	**0.745**
M3	0.378	

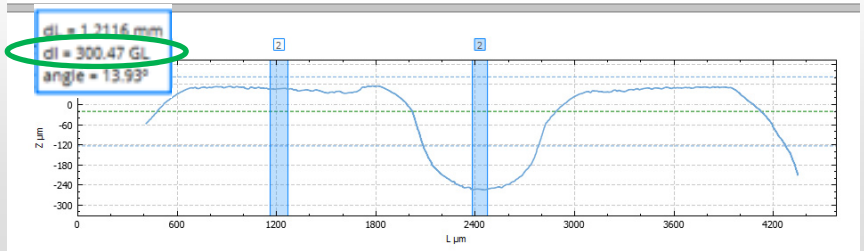
CRITICAL DIMENSIONS

CRITICAL DIMENSIONS

Firing pin impression depth measurements

SensoVIEW





Study by Luke Haag (Forensic Science Services)
3D2TWG (5th nov 2019)

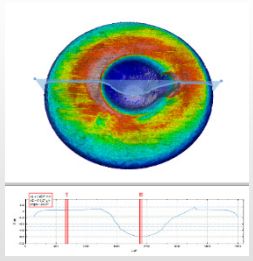
CRITICAL DIMENSIONS

Firing pin impression depth measurements

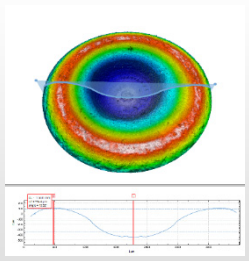
SENSOFAR. METROLOGY

Cartridge ID	Firearm ID	Origen	Firearm	Ammunition	FP Depth Manual	FP Depth Auto	Dif	Dif %
SRM2461	SRM2461	NIST	-	-	619.3	621.9	-2.6	0%
C1	R1	Guardia Civil	Revolver .38 Special 1	Plomo desnudo	697.8	664.6	33.2	5%
C2	R1	Guardia Civil	Revolver .38 Special 1	Plomo desnudo	554.4	527.4	27.0	5%
C3	R1	Guardia Civil	Revolver .38 Special 1	Semiblindada	696.3	674.3	22.0	3%
C4	R1	Guardia Civil	Revolver .38 Special	Semiblindada	553.2	531.9	21.2	4%
C5	P1	Guardia Civil	Pistola	9 mm corto	617.7	576.4	41.3	7%
C6	P1	Guardia Civil	Pistola	9 mm corto	471.3	437.6	33.7	7%
C11	P3	Guardia Civil	Pistola TAURUS	9 mm Parabellum	511.1	487.6	23.6	5%
C12	P3	Guardia Civil	Pistola TAURUS	9 mm Parabellum	517.4	499.0	18.3	4%
C14	P4	ADFS	Pistol Beretta	9 mm	323.3	363.8	-40.4	-13%
C15	P4	ADFS	Pistol Beretta	9 mm	300.5	304.2	-3.7	-1%
A	P5	WVU	SCCY	9 mm luger	420.1	398.2	21.9	5%
B	P5	WVU	SCCY	9 mm luger	480.6	423.3	57.3	12%
C	P6	WVU	SCCY	9 mm luger	476.4	448.6	27.7	6%

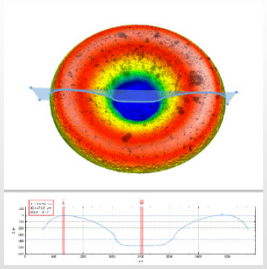
Units: micrometers *14 files / analysis time auto 120 s.*



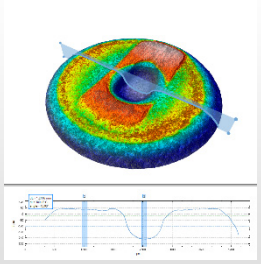
SRM2461



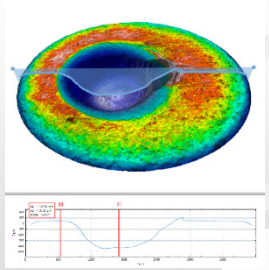
C3



C6



C15

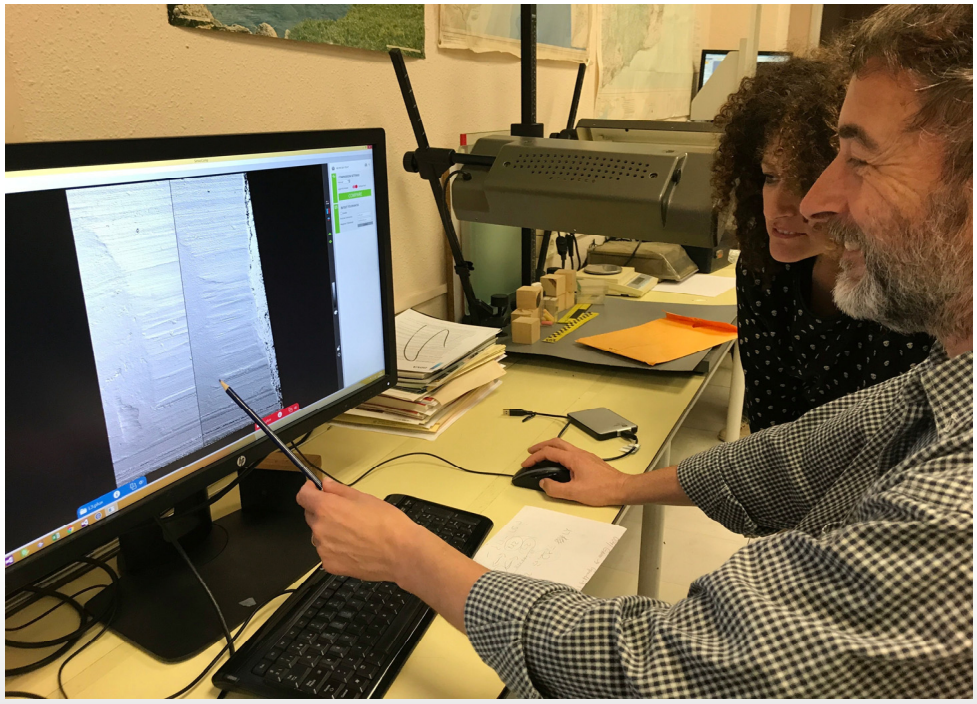


C

FUTURE

FUTURE

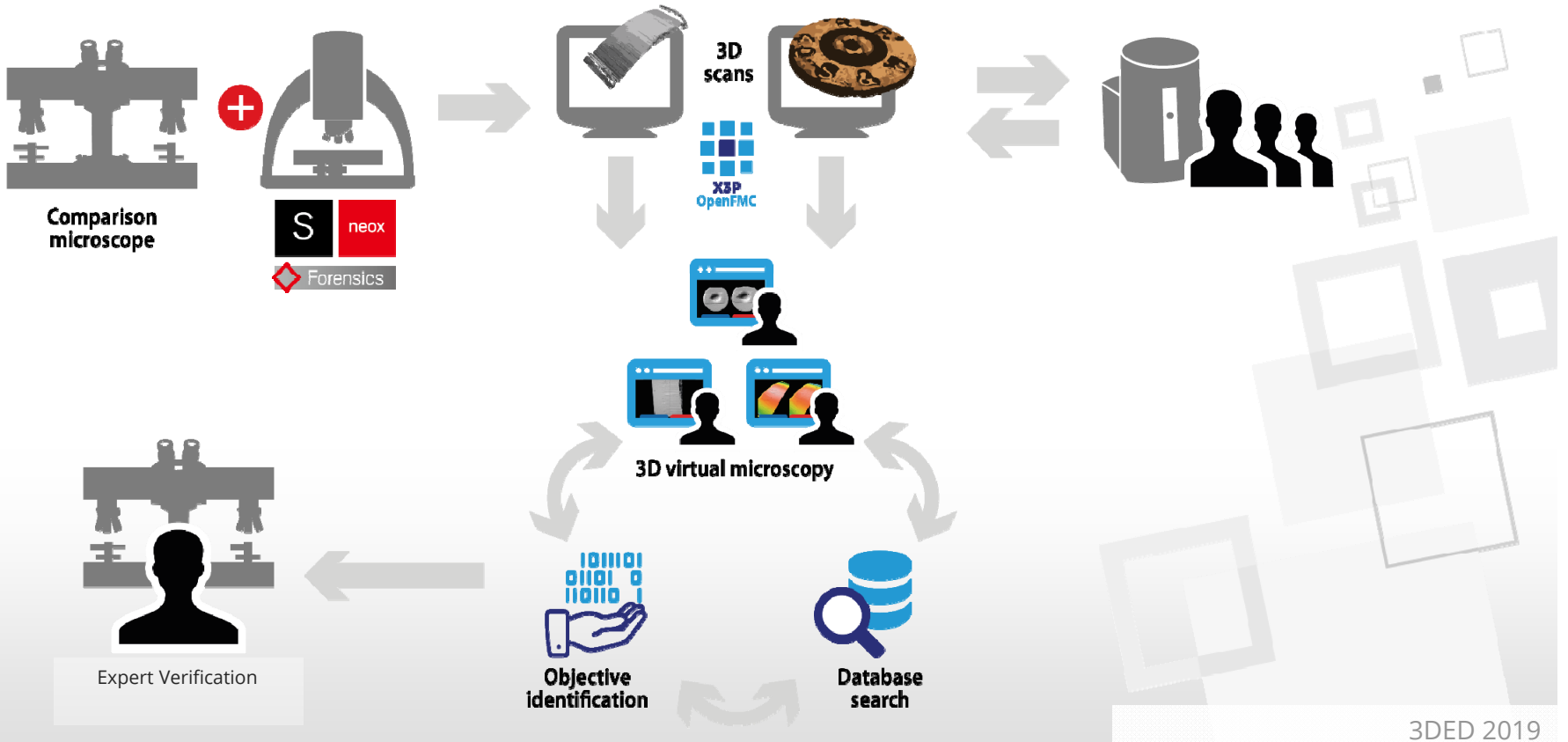
SENSOFAR. METROLOGY



Antonio and Sara, examiners at Guardia Civil (Barcelona) using VCM SensoCOMP

FUTURE

SENSOFAR. METROLOGY



Thank You!

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