

———— 32ND ANNUAL MEETING ————

ENFSI EWG

FIREARMS & GSR

———— 16th – 18th September 2026, Bucharest, Romania ————



— 32ND ANNUAL MEETING —

ENFSI EWG FIREARMS & GSR

— 16th - 18th September 2026, Bucharest, Romania —



Welcome address

Dear Firearms and GSR Experts, dear ENFSI Friends,

It is a great honour and a genuine pleasure to welcome you to Bucharest on the occasion of the 32nd ENFSI EWG Firearms & GSR Annual Meeting.

On behalf of the National Forensic Institute of the Romanian Police, I would like to extend to all of you my warmest welcome and my sincere appreciation for your presence here. We are particularly honoured to host such a distinguished community of forensic practitioners, researchers and experts, united by a shared commitment to scientific excellence and to the continuous advancement of forensic science.

This annual meeting represents far more than an opportunity to present scientific results. It is a forum where experience meets innovation, where established knowledge is critically examined, and where new ideas and professional partnerships can take shape. In a field as dynamic and demanding as firearms and gunshot residue examination, such exchanges are essential.

The abstract book accompanying this meeting reflects precisely this spirit. It brings together contributions that demonstrate the breadth, depth and vitality of current research and professional practice in our field. The studies and casework presented here address emerging challenges, explore new methodologies and perspectives, and illustrate how scientific knowledge continues to evolve in response to the increasingly complex demands of forensic investigation.

Behind each contribution lies not only scientific expertise, but also dedication, curiosity and a commitment to improving the quality and reliability of forensic evidence. I would therefore like to express my sincere appreciation to all the authors who have generously shared their work and expertise with this community.

At the National Forensic Institute of the Romanian Police, we strongly believe that the advancement of forensic science depends upon the close and continuous interaction between scientific research and professional practice. Research gains its true value when it responds to real forensic challenges, while professional practice progresses when it remains open to scientific innovation, critical assessment and new approaches. This is also the strength of ENFSI. For many years, ENFSI has provided an outstanding platform for cooperation, knowledge exchange and the harmonisation of forensic practice across Europe and beyond. We are proud to be part of this professional community and to contribute, through the expertise of our specialists, to the development of firearms and GSR examination.

I would like to take this opportunity to express my sincere gratitude to the ENFSI Board, to the Organising Committee, and to all those whose commitment and efforts have made this meeting possible. My particular thanks go to the reviewers, whose time, expertise and careful assessment have contributed significantly to the scientific quality of this programme and of the present abstract book.



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Also, I would also like to acknowledge and thank our exhibitors and supporting partners, whose contribution helps create the environment in which scientific dialogue, professional exchange and innovation can flourish.

I am confident that the discussions taking place during these three days will go well beyond the presentation of individual studies. I hope they will challenge assumptions, stimulate new ideas, strengthen existing partnerships and, perhaps most importantly, lead to new forms of cooperation that will benefit our profession in the years to come.

I encourage you to make the most of this meeting — to share your experience openly, to engage in constructive debate, to explore new perspectives and to build lasting professional connections.

Once again, it is my great pleasure to welcome you to Bucharest and to the 32nd ENFSI EWG Firearms & GSR Annual Meeting.

On behalf of the National Forensic Institute of the Romanian Police, I wish you a successful, inspiring and scientifically rewarding meeting, and I hope that your time in Bucharest will be both professionally enriching and personally memorable.

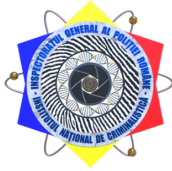
Thank you, and welcome to Bucharest!

Warm regards,

Dr. Romică POTORAC

Police Quaestor,

Director of the National Forensic Institute of the Romanian Police



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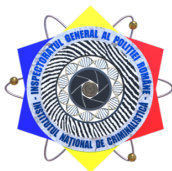
Exhibitors and Exhibition Area

LYON ROOM

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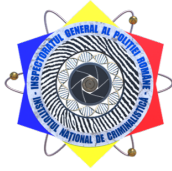
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OXFORD
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MICROSYSTEMS





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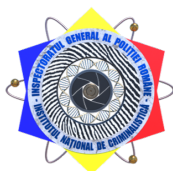
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ORGANIZATION

STEERING COMMITTEE

GSR	Firearms
Kal CHANA (Eurofins Forensic Services, UK)	Alice WALTERS (Metropolitan Police Service, UK)
Ruediger SCHUMACHER (BKA, Germany)	Thomas LIEBSCHER (BKA, Germany)
Sebastien CHARLES (NICC, Belgium)	Gregory JALABERT (SNPS, France)
Glenn ROEPNARAIN (NFI, Netherlands)	Pavel GIVERTS (DIFS, Israel)
Violeta DOBÂRCEANU (NFI, Romania) - <i>current host</i>	Fabiano RIVA (ESC/UNIL, Switzerland)
	Marlies BESTEBREURTJE (NFI, Netherlands) - <i>previous host</i>
	George DOBRIN (NFI, Romania) - <i>current host</i>

Supporting Staff of the National Forensic Institute of the Romanian Police

REGISTRATION DESK

Tuesday, September 15th 2026, 19:00 - 21:00

Wednesday, September 16th 2026, 08:00 - 11:00

WELCOME RECEPTION

(Novotel Bucharest City Centre)

Tuesday, September 15 th 2026	
17:00 - 19:00	Steering Committee Meeting
19:00 - 21:00	Registration & Welcome Reception



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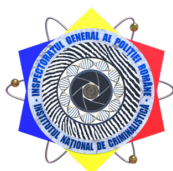
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ANNUAL MEETING PROGRAM

Wednesday, September 16 th 2026	
8:00 - 9:00	Registration & Coffee
9:00 - 11:00	Opening the 32nd ENFSI EWG Firearms & GSR Annual Meeting - Kal CHANA, Chairperson of the ENFSI EWG Firearms & GSR - Alexandru Poroșanu & Daniel Staicu, Deputy Directors of the Romanian Police National Forensic Institute
	Business Meeting
11:00 - 11:30	Coffee-Break/ Exhibition
COMMON SESSION	
11:30 - 12:30	Session chair - Kal CHANA
11:30 - 11:50	01 - Project VISTA: Seizure Databases and the Challenge of Privately Made Firearms in Europe Nicolas FLORQUIN
11:50 - 12:10	02 - Geometric detection of firearm components in consumer 3D-printing workflows: method, validation and failure modes Rachit BHOJANI
12:10 - 12:40	03 - MIX3D, 3D-printed firearms Carola LEVA, J. ECKERT, M. RUANO, D. FANINGER, K. HAMMER, C. BELLE, A. WOLF, K. ABRAHAMSSON, S. SVENSSON BERGKVIST, A. LUDWIG, D. D'ERCOLE
12:40 - 13:00	Group Photo
13:00 - 14:00	Lunch/ Exhibition
14:00 - 15:00	Session chair - Ruediger SCHUMACHER
14:00 - 14:30	04 - Case involving a self-made automatic firearm – homicide or accident? Miiika LOEFMAN, A. KORPI, J. SYRJAENEN, M. NYKAENEN
14:30 - 15:00	05 - Micro-XRF-based Analysis of Gunshot Residue Patterns for Objective Shooting Distance Estimation Jolene B.H. LOW, Alaric C. W. KOH
15:00 - 15:30	Coffee-Break/ Exhibition
15:30 - 17:30	Session chair - Gregory JALABERT
15:30 - 15:50	06 - Overview of the materials presented at the AFTE in 2025-2026 Pavel GIVERTS
15:50 - 16:10	07 - Addressing Emerging Challenges: The EU's Firearms Trafficking Proposal and Technical Rulemaking on 3D-Printed Firearms, Sound Moderators, and Semi-Finished Components Thomas LIEBSCHER
16:10 - 16:30	08 - Development and Application of Artificial Intelligence Algorithms in Shooting Incident Reconstructions Silvia FÁBREGUES-PONS, J. PÉREZ-ARACIL, J.L. FERRANDO, M. RUANO, C.CID, S. SALCEDO-SANZ
17:00	City tour



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Thursday, September 17th 2026

FIREARMS SESSION

8:30 - 9:00	Coffee-Break
09:00 - 11:00	Session chair - George DOBRIN
9:00 - 9:30	09 - Two examples of sub-class characteristics carryover in consecutively manufactured barrels Daniele D'ERCOLE, F. RIVA, L. LUCIERI, G. AMALFITANO, A. BAROMES
9:30 - 10:00	10 - Emergence and Forensic Implications of Clone Guns in Belgium Virginie REDOUTÉ MINZIÈRE, M. WARTEL, J.R. DAUBRESSE, E. HEYMANS, P. DE SCHUTTER, J. DE CEUSTER
10:00 - 10:30	11 - An Unusual Converted Firearm: The Class Characteristics Challenge Ali CETIN, Mehmet MERDIVENLI, Orhan AYAZ
10:30 - 11:00	12 - The Digiammo project – Exchange of 3D Forensic Ballistic Data Daan WINTERMANS, F. RIVA, J. ECKERT, K. HAMMER, G. CARUSO, D. ČÁRSKY, M. SIMONIC
11:00 - 11:30	Coffee-Break/ Exhibition
11:30 - 13:00	Session chair - Fabiano RIVA
11:30 - 12:00	13 – Determination of Firearm Model by the marks on Cartridge Case using Convolutional Neuron Networks Pavel GIVERTS, A. GRIBER, D. WINTERMANS, J. RAHM, V. WERNER, G. JALABERT, R. SVAGZDYS, Q. TOPALLI, F. RIVA
12:00 - 12:30	14 - Interoperability study of European ABIS systems Serge LÉVESQUE, A. BEAUCHAMP
12:30 - 13:00	15 - FARO Focus Premium 3D Scanning Solutions Alexandru STOICA, Radu HAIDUCU, Christian SCHÄFERS
13:00 - 14:00	Lunch/ Exhibition
14:00 - 15:00	Session chair – Thomas LIEBSCHER
14:00 - 14:30	16 - Bridging the Gap Between Examiner Conclusions and Score-Based Likelihood Ratios Xiaoyu Alan ZHENG, J. SOONS, S. LUND, E. SMITH, R. GOMINSKY
14:30 - 15:00	17 - Pursuing Objective Firearms Identification John SONG, H. SONG, K. MORRIS
15:00 - 15:30	Coffee-Break/ Exhibition
15:00 - 15:30	Steering Committee Meeting - only members of the Steering Committee
15:30 - 17:20	Session chair - Pavel GIVERTS
15:30 - 15:50	18 - From an Investigative to an Evaluative Approach: the Potential of Deep Learning Techniques for AK-47 rifles Identification Through Bullet Images Daan WINTERMANS
15:50 - 16:10	19 - Automation in Comparison Microscopy for Ballistics Jozsef GOMBOS
16:10 - 16:30	20 - BalScan – Versatile Solution for Ballistic Identification Michal MALÝ, M. SÁBL
16:30 - 17:20	21 - Rethinking the 2023 FAID Proficiency Test with Virtual Comparison Microscopy Bryan LEAHY, Serge LÉVESQUE
17:20 - 17:40	Closing the Meeting. Presentation of the next venue
19:00 - 22:00	Gala Dinner



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Thursday, September 17 th 2026	
GSR SESSION	
8:30 - 9:00	Coffee-Break
9:00 - 11:00	Session chair – Glenn ROEPNARAIN
9:00 - 9:30	22 - The prevalence of particles of interest (consistent or with limited association to GSR particles) as a tool for identifying cases that merit further investigation Sebastien CHARLES, C. TARENNE, F. VANNESTE
9:30 - 10:00	23 - Results and Consequences of the OOS on ASTM E1588-25 Ruediger SCHUMACHER
10:00 - 10:30	24 - The responsibilities of a SEM operator vs. a SEM service technician. Let´s get self-confident and competent for troubleshooting Dieter NEIMKE
10:30 - 11:00	25 - European Experiment on GSR Transfer and Persistence – Project Update and Discussion Hervé MÉNARD, K. ROBERTSON, G. ROEPNARAIN, P. BAKIS, K. CHANA, M. BOYLE, G. PISANI
11:00 - 11:30	Coffee-Break/ Exhibition
11:30 - 13:00	Session chair – Sebastien CHARLES
11:30 - 12:00	26 - Investigating extraction efficiency of organic gunshot residues from collection stubs Thomas TILBORG, C. WEYERMANN
12:00 - 12:30	27 - Gunshot residue interpretation under the CAI framework: are we addressing the right questions? Matteo GALLIDABINO
12:30-13:00	28 - A Compact Single-Field SEM/EDS Reference Sample for Routine GSR Quality Assurance Jeroen SMULDERS
13:00 -14:00	Lunch/ Exhibition
14:00 -15:00	Session chair – Violeta DOBÂRCEANU
14:00-14:30	29 - Parachute (rocket) flare residues analysis by SEM/ EDS: Update on the possible alternative sources Nikolaos STAVROU
14:30-15:00	30 - Gunshot residue profiling for source attribution: current approaches, limitations and future directions Jana Maria LIECHTI, Matteo GALLIDABINO
15:00 -15:30	Coffee-Break/ Exhibition
15:00 - 15:30	Steering Committee Meeting (only members of the Steering Committee)
15:30 - 17:20	Session chair – Kal CHANA
15:30 - 16:00	31 - Capabilities of GSR-Interpretation by Forensic Institutions of the Ministry of Justice of Ukraine: Methodological Approaches and Multimodal Identification Strategy for Classical Pb-Sb-Ba and Lead-Free Ammunition Anatolii KLYMENKO, O. POSILSKYI
16:00 - 16:30	32 - Forensic Value of Firearm Barrel Content Examination in GSR Casework Matthew GRIMA



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16:30 - 17:00	33 - Keep it in the Family: From Mom's Back to Grandpa's Grave. Are we wasting information avoiding different GSR compositions without reference samples? Ricardo HONORIO, Fatima MACHADO
17:00 - 17:20	34 - New Approaches to Non-Destructive Forensic Analysis: FTIR and Raman with Multivariate Analysis Barbara BRAVO, Angelo TRAINA
17:20 - 17:40	Closing the Meeting. Presentation of the next venue
19:00 - 22:00	<i>Gala Dinner</i>

Friday, September 18 th 2026	
FIREARMS SESSION - WORKSHOPS	
8:30 - 9:00	<i>Coffee-Break</i>
9:00 - 10:30	Workshop 1 - Observations on bullet holes in cars Axel MANTHEI
10:30 - 11:00	<i>Coffee-Break/ Exhibition</i>
11:00 - 13:00	Workshop 2 - ImpactA: AI Shooting Angle Calculation Manuel RUANO, José Luis FERRANDO, Silvia FÁBREGUES-PONS
13:00 - 14:00	<i>Lunch</i>
GSR SESSION - WORKSHOPS	
8:30 - 9:00	<i>Coffee-Break</i>
9:00 - 10:30	Workshop 1 - Does Europe need his own GSR standard? Ruediger SCHUMACHER
10:30 - 11:00	<i>Coffee-Break/ Exhibition</i>
11:00 - 13:00	Workshop 2 - Integrated Forensic Investigation of an Officer-Involved Shooting: From Crime Scene Examination to Event Reconstruction Jose Antonio RODRIGUEZ-PASCUAL, Alicia DOÑA-FERNANDEZ, Juan Francisco SAAVEDRA-ALVAREZ, Tomas CASADO-CHINARRO, Oscar MUÑOZ-PAULA, Iñaki MARTÍN-BARBER, Daniel VICENTE AYRA
13:00 - 14:00	<i>Lunch</i>



ABSTRACTS - COMMON SESSION

01 - Project VISTA: Seizure Databases and the Challenge of Privately Made Firearms in Europe

Nicolas Florquin^{1*}

¹ Small Arms Survey, Switzerland

* Correspondence: nicolas.florquin@smallarmssurvey.org

Abstract

The proliferation of illicit firearms in Europe heightens the risk of their use in organized crime, terrorism, and street violence. Despite regulatory efforts, Europe's intelligence picture remains patchy, constrained by a lack of systematic and harmonized seizure data collection. Project VISTA¹ addresses this gap by researching the European state of play regarding firearms seizure data collection, analysis, and dissemination to support EU-level policy and intelligence frameworks.

Initial research highlights complex challenges spanning data architecture, legal frameworks, personnel, resources, and technology. Crucially, stakeholders have varying operational and analytical priorities—ranging from immediate criminal prosecution to strategic trend analysis. These differing requirements directly impact the prioritized attributes of recorded data, such as accuracy, completeness, precision, and timeliness. Developing common minimum datasets requires balancing these needs while maintaining flexibility to capture emerging threats.

A prominent challenge in this landscape is the proliferation of Privately Manufactured Firearms (PMFs)—encompassing converted alarm weapons, 3D-printed/hybrid firearms, counterfeit weapons, guns assembled from partially finished components, and conversion devices. PMFs often elude existing categorization schemes, frequently being subsumed into vague classifications like 'other firearms'. Existing databases are primarily designed for police investigations rather than forensic intelligence or cross-border sharing, and do not systematically record critical technical markers, dual-use component origins, or non-serialized parts.

This intervention introduces Project VISTA's objectives and methodology regarding seizure databases and PMF proliferation. As this research is underway, a core aim is to engage the forensic community to:

1. Solicit participant interest in sharing national data and trends on recent PMF seizures to update previous assessments.
2. Gather operational experience on good practices and key technical parameters concerning PMFs that could be captured in seizure databases.
3. Foster collaborative dialogue between forensic practitioners and database developers to establish flexible, adaptable minimum datasets.

Keywords: Privately Made Firearms (PMFs), Firearm Seizure Databases, Data Harmonisation, Project VISTA.

¹ Project VISTA is an EU-funded initiative led by the Center for the Study of Democracy, alongside project partners Arquebus Europe, Ecorys, the Flemish Peace Institute, the Guardia Civil, the International Centre for Counter-Terrorism (ICCT), and Textgain, in collaboration with associate partners (the Belgian Federal Police, the Dutch Police, and the Bulgarian National Police) and subcontractor Small Arms Survey.

For more information please visit: <https://vlaamsvredesinstituut.eu/en/project-vista/>



02 - Geometric detection of firearm components in consumer 3D-printing workflows: method, validation and failure modes

Rachit Bhojani^{1*}

¹ Founder of SENTINEL (FabraForma), Mumbai, India

* Correspondence: bhojanirachit@gmail.com

Abstract

3D-printed firearms are usually approached forensically after manufacture. This contribution describes a method for identifying firearm components inside the digital file itself, at the point of slicing, and reports both its validation and its limits.

SENTINEL analyses print files — STL, CAD and G-code — geometrically. Rather than matching a file against a library of known blueprints, it segments the model into parts and classifies each part on its geometry, so a component is recognised on what it is shaped to do rather than on where it came from. Inference is local, approximately five milliseconds on printer-class hardware, with no file transmitted off the device. Engine v1.3 was validated over approximately 12,900 files. Part-segmentation accuracy is 0.999. The real-world false-block rate is approximately 3 per cent, falling to 0.22 per cent in production configuration.

Against deliberately modified and evasive files — rescaled, rotated, fragmented across separate prints, or geometrically perturbed — the catch rate is 92 to 100 per cent.

This paper presents the contribution on the failure modes and on the successes: the geometries that defeat segmentation; the legitimate parts that attract a false block, and why; the difference between recognising a receiver and recognising a component that is only a firearm part in context; and the adversarial cases not being solved. Also, it describes the corpus itself — how it was assembled, what it over-represents, and why a single-author dataset should be the basis on which anyone regulates.

Practitioners will be asked to assess detection claims made by manufacturers, and will want to know where those claims break.

Keywords: 3D-printed firearms, STL, CAD, G-code.



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03 - MIX3D, 3D-printed firearms

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Abstract

While the technology of Additive Manufacturing is constantly developing, hobbyists nowadays have access to high-quality materials and printers. Beside the constant improvement of the newly released 3D-printed firearms, this is the reason for these firearms to become increasingly stable and reliable.

The study MIX3D (Multinational Information EXchange for 3D-printed Firearms and Ballistic Data) addresses this topic by monitoring upcoming new designs of 3D-printed firearms, testing most promising models and improving methods for their forensic examination. Furthermore, an important aspect is the training of crime scene units and police forces.

Besides some models of 3D-printed firearms (e.g. Urutau, Not-a-Glock, Harlot, Ryno, FDMA 19.2), we tested 3D-printed silencers. The silencers were made of different filaments and attached to a conventional firearm. The noise reduction was determined and fired ammunition examined.

Knowledge on 3D-printed firearms and their forensic examination has already been gained through research. However, in real casework it turns out that issues arise, which were not foreseen during the research in the laboratory. Processes need to be established for the seizure and the forensic examination of 3D-printed objects that allow to gain as much information as possible while preserving traces for subsequent examinations.

Results of our experiments and experience with casework will be presented.

Keywords: 3D-printed firearms, 3D-printed silencers, MIX3D.



04 - Case involving a self-made automatic firearm – homicide or accident?

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Abstract

A case is presented, where a person was found deceased due to gunshot wounds inflicted with a self-made automatic firearm capable of firing 9 mm Luger ammunition. Evaluation of hypotheses involving accidental discharge and homicide required GSR examinations, other forensic case data being scarce.

Based on the spent casings, of the four shots fired, three rounds produced particles consistent with GSR (barium (Ba)-calcium (Ca)-silicon (Si)-type), and one round characteristic lead (Pb)-antimony (Sb)-barium (Ba)-particles. Samples from the victim, persons-of-interest (POIs), and their clothing led to negative results save for victim's cap. This called for a more thorough investigation on the potential for the firearm to spread GSR/consistent particles to shooter's hands.

Test firings were conducted using RUAG Action 6™ producing gadolinium (Gd)-titanium (Ti)-zinc (Zn) GSR-particles as well as cartridges producing Ba-Ca-Si-particles. The results indicated that the investigated firearm itself did not distribute GSR particles to shooter's hands as well as H&K SFP9-SF OR pistol in comparison. In addition, shooter's right hand was positive for Ba-Ca-Si-type particles, but barely exceeding the threshold for positive detection, and with forensically unfavorable size distribution.

Based on the results, the detection of the Ba-Ca-Si-particles may have been influenced by the inherent characteristics of the corresponding cartridges. Furthermore, the tested firearm presented unexpected particle discharge characteristics, which suggests a careful approach is required with GSR examinations related to self-made firearms. The negative test results from POIs and the victim could be put into a new perspective based on this study.

Keywords: gunshot residue, consistent with GSR, self-made firearm, accidental discharge, shooting test.



05 - Micro-XRF-based Analysis of Gunshot Residue Patterns for Objective Shooting Distance Estimation

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Abstract

Estimating muzzle-to-target shooting distance may be required for the reconstruction of shooting incidents. Traditionally, presumptive chemographic techniques have been used to visualise specific gunshot residue (GSR) patterns on target surfaces. However, these methods are element-specific and destructive in nature, with potentially poor visibility of the colour development on challenging substrates, and subjective inter-examiner interpretation, limiting the reliability of shooting distance estimation.

In this study, a micro-X-ray fluorescence (micro-XRF) method was developed for mapping and analysing GSR patterns on fabric substrates at varying shooting distances. The technique enables simultaneous, non-destructive detection of multiple GSR-associated elements with high-resolution spatial mapping, allowing a transition from qualitative visual estimation to a quantitative, data-driven approach. Elemental distribution maps were generated for key GSR elements, and a semi-automated data-processing workflow was developed to derive annular (ring-based) elemental ratio profiles at increasing radial distances from the bullet hole entrance. Shooting distance was estimated through algorithmic comparison of annular elemental ratio profiles between questioned and reference samples. This quantitative method was validated using proficiency test samples and benchmarked against independent visual assessments performed by trained firearm examiners.

The results demonstrate that micro-XRF provides a reliable and objective approach to shooting distance estimation, addressing the key limitations of traditional chemographic methods.

Keywords: gunshot residue (GSR), micro-X-ray fluorescence spectrometry (micro-XRF), elemental analysis, shooting distance estimation.



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06 - Overview of the materials presented at the AFTE in 2025-2026

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Abstract

The presentation is an overview of the most interesting materials that were published in the AFTE Journal and presented at the AFTE training seminar in May in Baltimore. The overview covers the period since the last meeting of the ENFSI Firearm/GSR EWG in 2025.

The goal of the presentation is to share the information about the main trends and subjects in the field of forensic firearm examination with European forensic examiners.



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07 - Addressing Emerging Challenges: The EU's Firearms Trafficking Proposal and Technical Rulemaking on 3D-Printed Firearms, Sound Moderators, and Semi-Finished Components

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Abstract

The proliferation of 3D-printed firearms and the illicit trafficking of firearms components pose significant challenges to law enforcement and regulatory frameworks across the EU. This presentation will provide an overview of the ongoing activities within the EU Commission (Home Affairs) working groups, focusing on two key areas:

1. The New Firearms Trafficking Proposal – An examination of the proposed measures to combat the illegal trade of firearms, with particular attention to the implications of **3D-printed firearms and digital blueprints**. The discussion will highlight how the proposal seeks to address gaps in current legislation while balancing security concerns with technological advancements.

2. Technical Rulemaking for Sound Moderators and Semi-Finished Components – An update on the working group's progress in defining **technical standards** for sound moderators (suppressors) and semi-finished firearm components. The presentation will explore how these rules aim to prevent circumvention of existing firearm regulations while ensuring clarity for manufacturers, law enforcement, and customs authorities.

Keywords: 3D Blueprints, 3D-printed Firearms, EU Firearms Legislation, Semi-finished Components, Sound Moderators.



08 - Development and Application of Artificial Intelligence Algorithms in Shooting Incident Reconstructions

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Abstract

The increasing prevalence of firearm-related crimes has intensified the demand for accurate and efficient forensic ballistic analysis. Traditional approaches for reconstructing ballistic trajectories, particularly for determining impact angles, typically rely on trigonometric approximations and physical measurement techniques, such as rods, lasers, and geometric calculations based on impact hole dimensions. However, many of these methods lack rigorous validation according to scientific standards and can therefore introduce significant errors.

Furthermore, reliable trajectory reconstruction often depends on highly experienced personnel who are not always available at the initial stages of crime scene investigation. To address these challenges, this research focuses on the development of artificial intelligence (AI) algorithms for ballistic trajectory reconstruction, with particular emphasis on predicting projectile impact angles from surface marks.

A comprehensive labeled dataset has been generated through controlled experiments conducted in collaboration with the Spanish Guardia Civil Criminalistics Service, incorporating a wide range of impact angles and surface materials. Based on this image dataset, deep learning models have been designed and trained, including convolutional neural networks (CNN) for feature extraction and ordinal classification algorithms that explicitly account for the ordered nature of impact angle categories. Preliminary results demonstrate the feasibility and potential of AI-driven approaches for improving ballistic trajectory reconstruction.

A proof of concept has been established, supporting the development of an operational tool for forensic practitioners.

Ultimately, this research aims to provide law enforcement agencies with a scientifically validated tool that complements traditional methods, enhances analytical reliability and optimizes resource allocation in criminal investigations.

Keywords: Artificial Intelligence, Shooting Incident Reconstruction, Convolutional Neural Networks, Deep Learning, Ballistics.



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ABSTRACTS - FIREARMS SESSION

09 - Two examples of sub-class characteristics carryover in consecutively manufactured barrels

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Abstract

This study presents two case studies of sub-class characteristics observed in manufacturing marks within firearm barrels.

The first case examines ten consecutively manufactured 9 mm Luger barrels for the Beretta mod. 92, highlighting the presence and distribution of subclass features.

The second case focuses on sub-class characteristics identified in barrel liners used in the assembly of 3D-printed firearms chambered in .22 LR.

In both cases, particular attention is given to the transfer and persistence of these characteristics on fired bullets, with implications for forensic firearm identification.

Keywords: Sub-class Characteristics, Consecutively Manufactured Barrels.



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10 - Emergence and Forensic Implications of Clone Guns in Belgium

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Abstract

Over the past year, Belgium has experienced an increase in the circulation of firearms that may be referred to as “clone guns”, counterfeit firearms which closely replicate authentic weapons and bear the markings of legitimate firearm manufacturers. These weapons are either inspired by or directly replicate widely used pistol models, such as the Glock 19 or Springfield Armory models like the XD 9 and XD-M Elite.

Owing to their undocumented origin and the absence of reliable identification features, these firearms can be classified as “ghost guns,” lacking effective traceability. Notably, some examined specimens have been found to bear identical serial numbers.

Their high degree of visual similarity to genuine firearms has made differentiation increasingly challenging, even for experienced forensic firearm examiners.

This growing phenomenon raises significant concerns regarding firearm traceability regulations as well as forensic investigations.

The present study aims to investigate this emerging issue in Belgium by quantifying the evolution of the circulation of such firearms over the past year. Additionally, the study seeks to identify distinguishing visual markers and functional characteristics that may enable reliable discrimination between genuine firearms and their replicas.

Particular emphasis is placed on the forensic examination of traces left on bullets and cartridge cases. Through this analysis, the study further aims to characterize the manufacturing processes underlying these clone firearms and to assess whether the resulting traces can be categorized as class, subclass, or individual characteristics.

Keywords: Clone guns, Glock, Springfield Armory.



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11 - An Unusual Converted Firearm: The Class Characteristics Challenge

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Abstract

Converted firearms are frequently used by criminals as one of the methods of illegal weaponry. By modifying the normal function of the weapons, they are rendered capable of firing live cartridges. The process is generally applied to weapons that are easily convertible. These weapons encompass various types, including alarm and signal weapons, salute and acoustic weapons, acoustic expansion, airsoft guns, air and gas guns, deactivated firearms, and Flobert pistols. In this study, a converted gas ram rifle, classified as an air and gas gun, was examined.

In connection with a suicide investigation, a converted gas ram rifle and a .22 caliber rimfire cartridge case lodged in the chamber, recovered from the crime scene, were submitted to the laboratory. Test firing was conducted to perform a cartridge case examination. Two test-fired cartridge cases were obtained under safety protocols using remote trigger station. Images of the comparison process were acquired using a Leica FSC comparison microscope (Leica Microsystems, Wetzlar, Germany) after a one-to-one comparison.

The design of firing pin holes and firing pins, which may be circular, rectangular, or elliptical, depending on manufacturing specifications, affects the development of class characteristics. However, firing pins from converted firearms manufactured in workshops can exhibit unique characteristics that have not previously been observed in firearm examination practice. In the study, the firing pin impression on the evidence cartridge case exhibited a distinctive and unusual shape.

When examining cartridge cases fired from converted firearms, forensic examiners often encounter irregular striae and impressions. These inconsistencies result from the manufacturer's practical solutions for the firing mechanism and the quality of raw materials used for replacement parts. Therefore, accurate determination and comparison of both class and individual characteristics have become essential for cartridge cases fired from the wide variety of converted firearms.

Keywords: Class Characteristics, Converted Firearms, Firing Pin Impression, Gas Ram Rifle.



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12 - The Digiammo project – Exchange of 3D Forensic Ballistic Data

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Abstract

The Digiammo project ² aims to test the interoperability of various ABIS systems used across ENFSI laboratories through the exchange of .x3p files.

The project explores the feasibility of exchanging 3D topography models of cartridge cases and bullets among the laboratories in order to identify the spent cases and the bullets fired from the same weapon in an innovative way able to facilitate remote collaboration, blind verification, training and the development and execution of Proficiency Tests.

To achieve this, it is crucial to assess whether .x3p files can be generated, imported, visualized, and compared (VCM) with the same accuracy and efficiency across all available ABIS platforms.

As this project is coming to an end, the aim of this presentation is to share the final results and conclusions regarding the proficiency test that was implemented and distributed across various laboratories in Europe.

Keywords: ABIS, Interoperability, Proficiency Test, Virtual Comparison, x3p files.

² The Digiammo is a working package part of the FOR-FUTURE project started in 2024.

The Digiammo team includes 10 persons from 4 different European laboratories (BKA (DE), RaCIS (IT), Institute of Forensic Science from Slovak Republic (SK) and University of Lausanne (CH)).



13 - Determination of Firearm Model by the marks on Cartridge Case using Convolutional Neuron Networks

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Abstract

Determination of the possible firearm type and model based on class characteristics presented on fired cartridge cases is an important stage of forensic firearm examination.

This study is dedicated to the developing of an objective method of such determination based on the analysis of images of the headstamp area of cartridge cases by convolutional neural networks (CNN).

A dataset of 30 930 images representing 4 291 firearms was collected from several ballistic identification systems and divided into 37 classes. During the research eight CNN architectures were trained and evaluated: Xception, InceptionV3, InceptionResNetV2, ResNet50, DenseNet121, ConvNeXtTiny, ResNet101V2 and EfficientNetV2S.

The evaluated models showed similar performance, with Top-1 accuracy of approximately 60–65% and Top-3 accuracy of approximately 78–82%.

When domain-based acceptance rules were applied to the account, similarities between classes, accuracy increased to approximately 69–73% for Top-1 and 90–92.5% for Top-3.

Ensemble configurations provided a modest additional improvement, with the best ensemble reaching a domain-based Top-3 accuracy of 93.35%.

Using the results of the research a free-access web-application for the analysis of images and the determination of possible firearm classes was developed.

Keywords: Firearms Examination, Firearm Model Determination, Class Characteristics, Convolutional Neuron Network, Machine Learning.



14 - Interoperability study of European ABIS systems

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Abstract

The European landscape of automated ballistic identification systems (ABIS) is dominated by three main tools: Balscan, IBIS, and Evofinder. It has long been accepted that 2D images from these systems were fundamentally incompatible for algorithmic comparison aimed at identifying traces of common sources among a large number of specimens.

The development of topographic image sensors by ABIS equipment manufacturers combined with the establishment of the X3P exchange format for 3D images (X3P) offers hope that algorithmic comparisons between 3D images from different instruments will be feasible and thus facilitate cross-border investigative leads and pan-European firearm-related intelligence.

The preceding statement is based on a fundamental, unstated assumption, that all topographic image sensors provide identical information that accurately represents an object's surface. However, this assumption is incorrect.

Different topographic image sensors each have their own specific characteristics regarding measurement traceability, signal-to-noise ratio, lateral resolution, etc. To what extent do the differences in imaging characteristics among the three systems hinder the goal of interoperability?

To being answering this question, EMPACT sponsored the creation of a dataset of topographic images of 100 known-match pairs of 9 mm cartridge cases captured using the Balscan, IBIS, and Evofinder instruments located in Spain. This dataset was shared among the instrument providers using the X3P format.

We present here the results of the interoperability analysis of these ABIS systems. We conclude that the topographic images of breech marks captured by the different instruments are highly compatible in terms of generating investigative leads. This is not the case for the images of the firing pin mark.

Ultimately, the overall results regarding the identification of common sources in large heterogeneous image datasets are somewhat affected, but without compromising the usefulness of inter-system comparisons.

Keywords: 3D images, Interoperability, Investigative leads, X3P.



15 - FARO Focus Premium 3D Scanning Solutions

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Abstract

FARO INSIGHT AMETEK, with over 40 years of experience, offers a comprehensive range of high-precision 3D solutions tailored for various application fields, including forensic science, construction, industry, and research. The company's portfolio includes specialized solutions to meet diverse needs, from large-scale scans to extremely fine details, ensuring top-quality, reliability, and high performance. Since 2010, RO-MEGA TRADE has been the official representative in Romania, playing a crucial role in promoting and providing technical support for advanced equipment and technologies, including FARO solutions. RO-MEGA's primary role in Romania is to deliver practical demonstrations of FARO technology, highlighting its high-precision 3D scanning capabilities for crime scene reconstructions, sample scans, and forensic analyses. The company also provides technical support, maintenance services, and consulting for FARO equipment users in the fields of criminalistics, public safety, and other industrial applications.

The connection to public safety is direct and significant, as FARO technology is used for crime scene reconstructions, 3D scans of evidence, scene analysis, and other forensic activities. These solutions contribute to increasing the accuracy and efficiency of investigations, facilitating the achievement of precise and rapid results in complex cases.

FARO's 3D scanning solutions offer a variety of models adapted to different documentation and inspection needs. For large and complex projects, the **Focus Premium Max reaches up to 400 meters**, providing exceptional accuracy and rapid processing speed, making it ideal for inventory, monitoring, and technical documentation at long distances. **Long-range scanning (up to 400 m):** High accuracy and data fidelity, fast and efficient for large-scale projects, utilizing advanced Laser and HDR technology, suitable for documentation, construction, architecture, and topography.

FARO Focus Premium (up to 200 m): Versatile for field documentation, evaluations, and technical inspections, delivering reliable and detailed results, suitable for engineering, architecture, and construction applications, functioning well both outdoors and indoors.

FARO's solutions, especially the **FARO Zone 3D software and 3D scanning devices**, are used for:

- **Crime scene reconstruction:** Enabling digital recreation of scenes to provide clear, accurate visualizations that help understand the dynamics of an incident.
- **Evidence documentation:** Precise 3D scans record the position and condition of objects and environment, supporting further analysis and courtroom presentations.
- **Ballistics analysis:** When combined with other technologies, FARO solutions assist in determining projectile trajectories, identifying firearm types, and verifying evidence compatibility.
- **Public safety and prevention:** In emergency situations, these technologies allow rapid scene assessment, risk identification, and implementation of protective measures for the population.

Keywords: 3D scanning solutions, 3D software, Ballistics analysis.



16 - Bridging the Gap Between Examiner Conclusions and Score-Based Likelihood Ratios

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Abstract

As the forensic landscape evolves, the 'expert eye' in firearm toolmark analysis is increasingly being reinforced by objective statistical validation.

This project evaluates the parity between visual toolmark comparisons and algorithmic measures for the strength of evidence, specifically score-based likelihood ratios (SLRs).

Responding to concerns from the 2009 National Academies and 2016 PCAST reports regarding the lack of objective forensic standards, the FBI, NIST, and the Netherlands Forensic Institute developed the Reference Database of Firearm Toolmarks (RPDFT) system. This system generates known same source and known different source distributions from reference data to provide a quantitative weight of evidence for one-to-one comparisons.

Building on the FBI/ AMES II Decision Analysis Study, a "black box" study involving 173 examiners and 4,320 fired cartridge case comparisons, this research applies the RPDFT system to generate a SLR for each of the 1,275 sampled comparisons in that study. The primary objectives include:

- Evaluating the range of likelihood ratios associated with each of the AFTE conclusion scales;
- Determining if "inconclusive" results are statistically supported by the algorithm;
- Assessing whether algorithmic estimates could mitigate false positives or negatives;
- Identifying the inherent limitations of SLRs compared to human expertise.

By establishing foundational knowledge on the alignment between examiner conclusions and SLRs, this work represents a critical milestone for integrating objective statistical weight of evidence measures into forensic testimony and strengthening the scientific validity of firearm identification.

Keywords: Firearm Toolmark, Score-Based Likelihood Ratio, Weight of Evidence.



17 - Pursuing Objective Firearms Identification

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Abstract

Firearms identification faced challenges to its fundamental assumption and error-rate reporting.

Since the 1990s, theoretical and experimental approaches are developed to provide scientific foundation, comparison algorithm, statistical model, and likelihood ratio (LR) report.

Since the 2000s, these approaches are used to support objective firearms identification and quantitative expression of the weight of evidence. However, there are some concerns to be addressed: 1) the currently used algorithms may exhibit false positives, 2) the currently used dataset structure couldn't ensure an unbiased LR estimation, and 3) the current LR reports show astronomically high LR values that couldn't be used to support firearm examiner's casework and court testimony – it is too good to be true.

By addressing these issues, we propose a novel experimental approach based on test fires to assess the repeatability and reproducibility (R&R) of the firearms and datasets.

It is free from tedious theoretical derivations and is easy to understand and use in casework. It can fully leverage the information provided by the high identification scores while avoiding the unsupported high LR values.

A set of functional parameters is developed to quantify the dataset structure, evaluate image quality, and predict its performance in image comparison. The identification criterion with the LR and uncertainty is developed for firearms identification. A safety margin with 95% confidence level is used for quality assurance (QA) in firearm examiners' casework. A corresponding LR verbal scale can be used to support court testimony.

In this study, three sets of firearms are used to establish the dataset structure and calculate the functional parameters. Four sets of tests are performed to verify the results. The verification results support the established dataset structure and the calculated functional parameters.

Keywords: Congruent Matching Cells (CMC), Firearms Identification, Likelihood Ratio (LR), Quality Assurance (QA), Repeatability and Reproducibility (R&R).

³ **Dr. Junfeng John Song** was invited by the National Bureau of Standards (NBS, now NIST) in 1987 served as a guest scientist in surface metrology. In 1997, he was a project lead (until 2018) and a postdoctoral research advisor (until 2025) of the forensic topography & surface metrology project at NIST.

In 2017, he was awarded a Ph.D. by University of Warwick (UW, UK) for his published works in surface and forensic topography metrology.

In 2019, he was awarded a NIST Allen V. Astin Measurement Science Award: "For revolutionizing firearm forensics by discovering a robust statistical method for attributing cartridge case evidence to a specific firearm."

In 2025, he retired from NIST and was invited by West Virginia University (WVU) served as an adjunct professor in forensic & investigation science.



18 - From an Investigative to an Evaluative Approach: the Potential of Deep Learning Techniques for AK-47 rifles Identification Through Bullet Images

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Abstract

In 2016, increasing automation and reducing subjective human inputs are the main points raised by the PCAST report for scientific validity in firearm examinations. When these points are mentioned, it is no longer possible to overlook the question of whether artificial intelligence could be used to help solve this problem. With this idea and with their ability to process a great amount of raw data, Convolutional Neural Networks (CNN) are a class of Deep Learning models able to extract features on images for classification purposes.

In this study, we implemented several CNNs to explore their potential for classifying 200 AK-47 rifles of the same model.

After identifying typical firearm-related issues, we achieved 96% of top-1 accuracy for a specific class of model across the 200 classes.

Given these results, it is all the more important to exploit these models for operational purposes.

This presentation explores how different forensic approaches can be applied to the outputs of Convolutional Neural Networks, moving from an investigative approach in which the models' classification architecture serves as a tool for firearm examiners, to an evaluative approach in which transparent uncertainty plays a central role in reporting results.

Keywords: Artificial Intelligence, Classification, Firearms, Identification, Likelihood Ratio.



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19 - Automation in Comparison Microscopy for Ballistics

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Abstract

Modern ballistic laboratories face increasing caseloads while being expected to deliver fast, reliable, and fully documented examination results.

Automation in comparison microscopy is becoming an essential tool for improving efficiency, reducing repetitive manual tasks, and ensuring consistent, reproducible examinations.

This presentation demonstrates how automation can enhance virtually every stage of ballistic microscopy.

Motorized evidence holders eliminate time-consuming manual repositioning by allowing bullets and cartridge cases to be rotated, tilted, and recalled to previously stored positions with exceptional precision.

This enables examiners to concentrate on interpreting microscopic features rather than manipulating the evidence.

Advanced imaging functions such as Extended Depth of Focus (EDF) automatically generate fully focused, rotatable 3D images, allowing complex surface features to be examined more efficiently than with conventional focal stacking.

Combined with premium optics and precise motorized controls, these capabilities provide clearer visual information while shortening examination time.

Overall, the presentation illustrates that automation is not intended to replace the expertise of the ballistic examiner.

Rather, it removes repetitive mechanical operations, standardizes documentation, improves reproducibility, and streamlines routine workflows, allowing forensic experts to focus their time and attention on the critical task of evaluating ballistic evidence.

Keywords: Automation, Comparison Microscopy, EDF.



20 - From an Investigative to an Evaluative Approach: the Potential of Deep Learning Techniques for AK-47 rifles Identification Through Bullet Images

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Abstract

Laboratory Imaging s.r.o. (LIM) brings more than 35 years of expertise in microscopy, image processing, and analysis, developing laboratory systems for forensic science, including firearms investigation, shoeprint scanning and comparison, toolmark examination, fingerprint comparison, and refractive index measurement and microspectroscopy.

LUCIA BalScan is a versatile, complete, high-performance ballistic identification solution based on a universal scanner with custom-designed optics providing 3D images at 3 µm/px resolution and exceptional image quality. An alternative color camera offers the same 3D quality with color texture, giving a new perspective on cartridge cases and bullets.

New HDR texture capture combines multiple exposures into a single image, preserving detail in both highly reflective and dark areas and eliminating over- or underexposed spots on demanding metallic surfaces.

New multi-texture capture allows several texture images, for example, under different lighting directions, to be stored with a single 3D topography, letting the examiner switch between them to reveal fine tool marks.

New front light option enhances the detail of firing pin area.

Scanning speed has been increased, and difficult objects, including highly deformed bullets, bullet fragments, double casts, cartridge case surfaces, cartridges in a container, or firearms parts and their casts, can be scanned using expert settings. Cartridge scanning can be further accelerated using a 4-CC or 12-CC holder.

Data archiving, organizing, searching, and sharing within the organization or with other institutes are integral to the system. Database scales from a size for single laboratory to a country-wide solution with synchronized databases. Our implementation of the X3P format means BalScan can open any X3P file that meets the specification, treat it as a native file for virtual comparison microscopy or database search. Also export images to X3P is supported.

Continuous software development focuses on simplifying the workflow for everyday objects while retaining versatility through expert settings and tools.

Keywords: 3D Surface Scanning, Ballistic Identification, HDR Texture Capture, Multi-Texture Imaging, Virtual Comparison Microscopy.



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21 - Rethinking the 2023 FAID Proficiency Test with Virtual Comparison Microscopy

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Abstract

Virtual comparison microscopy (VCM) is changing how firearms examiners acquire, share, and evaluate evidence — enabling side-by-side comparison of 2D and 3D surface data independent of the physical exhibits.

This presentation looks at the 2023 FAID proficiency test through a VCM lens, revisiting the fired cartridge case and bullet comparisons using digital exhibits in place of the physical set.

Quantitative analysis techniques will be applied to this well-characterised dataset — moving beyond visual assessment to compute objective similarity scores, false match rates, and likelihood ratios that can be compared with examiners' original conclusions.

The session will highlight where quantitative and traditional visual findings align, where they diverge, and what that means for interpretive decisions: how examiners weigh agreement of individual characteristics, handle borderline comparisons, and express conclusions on the ENFSI A–E scale.

Aimed at both newcomers to VCM workflows and experienced examiners, the session offers a concise, evidence-based look at how quantitative tools can complement — and be benchmarked against — established comparison microscopy practice.

Keywords: Virtual Comparison Microscopy (VCM), 2023 FAID Proficiency Test.



ABSTRACTS - GSR SESSION

22 - The prevalence of particles of interest (consistent or with limited association to GSR particles) as a tool for identifying cases that merit further investigation

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Abstract

It is recommended to adopt a case-by-case approach when analysing GSR. This approach requires an investigation of ballistic references, ideally through the conduction of test firings, or alternatively by analysing cartridge cases, to determine the type of GSR particles produced and thus establish the type of particles to look for on items linked to a POI.

In routine practice, this case-by-case approach is not systematically applied, due to established habits and sometimes a lack of time.

Over the past two years, following the acquisition of two new SEM/EDS systems, the NICC has been monitoring the levels of all particles of interest detected, including the consistent ones and those with limited association to GSR particles.

The purpose of this study is to identify potential situations where an unusually high number of one (or more) type(s) of particles belonging to these classes merits further investigation of ballistic references.

The presentation of results in the expert reports has also been redesigned to improve readability and to highlight any classes of particles that may be of interest.

The presentation will review the prevalence data obtained during this two-year study and will include a few cases where this strategy has yielded interesting results, leading to a reconsideration of the nature of the particles of interest.

Keywords: Case-by-case approach, prevalence, consistent particles, limited association, ballistic references.



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23 - Results and Consequences of the OOS on ASTM E1588-25

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Abstract

In March 2026 the EWG FAGSR organized an online One-Day-One-Topic-Seminar addressing concerns of the GSR experts regarding a revision of E1588.

A survey on the new revision has been conducted and critical issues have been identified leading to an open letter to OSAC/ASTM.

The ongoing activities of OSAC regarding the revision of E1588-25 and possible consequences for European GSR experts will be discussed.

Keywords: ASTM E1588-25, Standardization, GSR Analysis, SEM-EDS.



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**24 - The responsibilities of a SEM operator vs. a SEM service technician.
Let 's get self-confident and competent for troubleshooting**

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Abstract

With nearly 29 years of experience in the field of scanning electron microscopy (SEM), I would like to present some of the most significant pitfalls and errors associated with SEM systems that have been identified in various forensic laboratories in Germany and other European countries, including our own laboratory.

The examples are intended to sharpen operators' awareness of unusual behavior in their systems and encourage them to think beyond standard operating procedures (SOPs).

The cases mentioned in the presentation could help users critically evaluate the results of gunshot residue (GSR) analysis and work with confidence and competence.

The operator of such a device uses it for many hours every day, while a service technician may visit the site only once a year.

Therefore, the SEM user is responsible for the quality of the measurements and should strive to understand the technical processes and the physics of the system in detail.

Keywords: GSR Analysis, SOPs, SEM.

⁴ **Dieter Neimke** has been a member of staff in section KT41 (Central Analysis Laboratory 1 / GSR Traces) at the Federal Criminal Police Office since 1997. His main area of responsibility is the operation of SEM/EDS and XRF systems, primarily for GSR investigations, as well as the development and optimization of the relevant applications. He has been involved in numerous forensic research projects and the development of proficiency tests.

Since 2013, he has been a lecturer at the ENFSI GSR Summer School and has also delivered numerous presentations at ENFSI conferences.



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25 - European Experiment on GSR Transfer and Persistence – Project Update and Discussion

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Abstract

The European GSR Transfer and Persistence Project is an international collaborative study aimed at generating robust data on the mechanisms of gunshot residue (GSR) transfer and its persistence on human hands under controlled conditions.

The project focuses on quantifying direct and indirect GSR transfer during and after firearm discharge, including scenarios involving bystanders, secondary handling of the firearm, and handshakes.

A standardised protocol was developed to promote consistency across participating institutions, using the same weapon model (Glock 19), ammunition (9×19 FMJ Geco), and sampling and analysis techniques (SEM-EDS following ASTM E1588-20).

Data collection and analysis are ongoing, with this part of the project scheduled to continue until June 2027.

This talk will provide an opportunity to discuss progress to date and, importantly, how participating institutions can work collaboratively to maximise data collection and analysis within the remaining project timeframe.

Additional contributions are strongly encouraged, including from institutions that are only able to undertake a limited number of experiments or replicates, as even partial contributions can provide valuable data to broaden the dataset and strengthen the evidence base for activity-level reporting in forensic GSR interpretation.

Keywords: European GSR Transfer and Persistence Project, SEM-EDS.



26 - Investigating extraction efficiency of organic gunshot residues from collection stubs

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Abstract

When shooting a firearm, a projectile is propelled by the weapon. The ignition of the ammunition produces chemical species and particles, usually invisible to the naked eye, that are released in the environment and can be found on persons and objects surrounding the discharge of a firearm. Those particles and compounds are referred to as gunshot residues (GSR) and can be organic (OGSR) or inorganic (IGSR).

To collect those residues on the hands of a person, a stub is generally used.

The aim of this study was to investigate the efficiency of the extraction method for OGSR compounds from the stubs. The extraction was carried out by applying a solvent on the adhesive of the stub, then the solvent is recovered and analysed with a liquid chromatography coupled to a tandem mass spectrometer (LC-MS/MS).

In the first step, known concentrations of the targeted organic compounds were put on stubs and were then subjected to multiple repetition of the extraction method. After this step, the same protocol was applied on stubs applied on the hands of shooters shortly after they discharged a firearm.

In both experiments, higher concentrations of the compounds were collected during the first extraction than in the following extractions.

It was concluded that one application with 100 µL of solvent was sufficient to extract on average 70% of the OGSR compounds.

Keywords: Firearm discharge residues, Forensic Science, LC-MS, Organic compounds, Sequential analysis.



27 - Gunshot residue interpretation under the CAI framework: are we addressing the right questions?

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Abstract

Gunshot residue (GSR) analysis has reached a high degree of analytical maturity, particularly for the detection and classification of inorganic particles by SEM/EDS. However, determining what GSR findings mean in the circumstances of a case remains difficult. In recent years, GSR interpretation has increasingly adopted the language of Bayesian reasoning, likelihood ratios and the Case Assessment and Interpretation (CAI) framework. This does not necessarily mean that the underlying evaluative logic has been implemented consistently.

This presentation critically examines current GSR evaluative practice against selected CAI principles, with particular attention to the questions addressed, the hierarchy of propositions and the distinction between investigative explanations and evaluative propositions. Three recurring conceptual problems are identified.

First, comparisons such as GSR versus non-GSR are frequently described as source-level questions, although they primarily concern trace identification or classification.

Secondly, activity-level propositions are often formulated too generically, for example as discharge versus non-discharge, and may therefore remain remote from the specific issue in the case.

Thirdly, some formulations incorporate transfer mechanisms, contamination routes or observations directly into the propositions, potentially making the findings expected by definition and weakening the assessment of their evidential value.

To address these problems, a staged interpretative framework is proposed. It distinguishes analytical interpretation, trace identification and significance assessment, before selecting the appropriate source, sub-source or activity level. It also requires propositions to be case-specific while keeping findings, mechanisms and explanatory variables outside the propositions themselves.

The proposed framework does not replace existing analytical standards or probabilistic models. Rather, it clarifies the questions those tools can properly support and provides a basis for more transparent, relevant and logically coherent GSR reporting.

Keywords: Bayesian reasoning, Case assessment and interpretation, Evaluative reporting, Propositions, Likelihood ratio.



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28 - A Compact Single-Field SEM/EDS Reference Sample for Routine GSR Quality Assurance

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Abstract

The revised ASTM E1588-25 places renewed emphasis on positive-control checks in automated gunshot-residue (GSR) particle analysis, including the demonstration that particles around 1 µm can be detected and identified. In daily laboratory practice, this requirement is difficult to cover with a single existing check.

Beam-current monitoring, BSE brightness checks and EDS count-rate monitoring each address only part of the SEM/EDS chain, while full proficiency-test style samples are too time-consuming for repeated use before casework.

This presentation describes the design and intended use of a compact SEM/ EDS reference sample for routine GSR quality assurance.

The GSR_C1 sample combines, on one 12.5 mm aluminium pin stub, supporting reference areas for BSE contrast, EDS resolution, EDS energy calibration and beam-current measurement with a compact single-field particle-size matrix.

The proposed workflow is a short-automated measurement before, or at defined intervals during, case-sample analysis.

Results can be evaluated by counting detected and correctly classified structures per size row against laboratory-defined acceptance criteria.

Keywords: GSR, SEM/EDS, ASTM E1588-25.



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**29 - Parachute (rocket) flare residues analysis by SEM/ EDS:
Update on the possible alternative sources**

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Department/ Gunshot Residues Analysis Laboratory, GREECE

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Abstract

Following our work on the parachute (rocket) flare residues analysis by SEM/ EDS that we had presented at the 31st ENFSI EWG Firearms & GSR AM, we have analyzed residues from 4 activated handflares and 1 pen-like flare ejection device.

Environmental samples have also been analyzed and respective air pollution literature review has been updated.

Comparative results of the afore-mentioned alternative sources residues to specific parachute flare residues have shown that source discrimination may be possible.

Keywords: Flare, parachute, pyrotechnics, residues, rocket.



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30 - Gunshot residue profiling for source attribution: current approaches, limitations and future directions

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Abstract

Gunshot residue analysis routinely supports trace identification and activity-level assessment in firearm investigations.

Less attention has been given to a distinct source-level question: whether a characterised GSR trace can be associated with a particular discharge-related source, such as an ammunition type or firearm-ammunition combination, rather than another.

This review examines current approaches to profiling inorganic and organic GSR, assesses their analytical and interpretative scope, and identifies priorities for further research.

Keywords: Profiling, Chemometrics, Evidential evaluation, Source comparison, Forensic Interpretation.



31 - Capabilities of GSR-Interpretation by Forensic Institutions of the Ministry of Justice of Ukraine: Methodological Approaches and Multimodal Identification Strategy for Classical Pb-Sb-Ba and Lead-Free Ammunition

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Abstract

The interpretation of gunshot residue (GSR) by forensic institutions of the Ministry of Justice of Ukraine is based on classical morphological analysis and modern elemental profiling. The main strategy of multimodal identification involves scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM/EDS) as the gold standard for the detection of both classical Pb-Sb-Ba systems and lead-free (ecological) ammunition.

In expert practice, GSR analysis is aimed at two key tasks: identifying the nature of microparticles and establishing the fact of the shot.

The proposed multimodal identification involves preliminary screening using portable X-ray fluorescence (XRF) for rapid elemental mapping of large surfaces. This identifies concentration zones of lead (Pb), antimony (Sb), and barium (Ba) for classic ammunition, or markers such as strontium (Sr), titanium (Ti), zinc (Zn), aluminum (Al), tin (Sn), gadolinium (Gd), and lanthanum (La) for lead-free ammunition where Sr, Ti, Gd, and La serve as markers in initiating substances, such as CleanRange capsules.

The next step is detailed SEM/ EDS microscopy to confirm the presence and morphology of fused spherical particles for classic ammunition, or irregularly shaped Ti-Zn and Sr-Al-Sn particles for lead-free ammunition.

Finally, the use of LC-MS/MS or GC-MS methods to identify organic products of the shot (residues of combustion products and powder stabilizers such as diphenylamine, nitroglycerin and cetralites), which, in combination with SEM/EDS, allows for the creation of a “chemical fingerprint” of the shot even in the absence of lead.

The novelty of this approach lies in the ability to differentiate lead-free GSR from environmental particles containing K, Al, Si, and Ca. Also, the integration of inorganic and organic mapping significantly increases identification accuracy, ensuring reliable expert conclusions for modern ammunition.

Keywords: gunshot residue, SEM/EDS, X-ray fluorescence.



32 - Forensic Value of Firearm Barrel Content Examination in GSR Casework

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Abstract

This work demonstrates the forensic value of a full firearm barrel reference washout combined with an infrared-assisted solvent evaporation approach for resolving unusual inorganic gunshot residue (GSR) populations encountered during SEM-EDS examination.

In two firearm-related investigations, SEM-EDS examination of particles recovered from suspects' hands revealed an unusual population with elevated iron and chromium content, creating uncertainty in interpretation.

Examination of barrel washout residues, prepared using ethanol and infrared-assisted solvent evaporation, proved critical in clarifying their origin.

The recovered material showed metallic Fe-Cr fibres, Fe-Cr particles, and "characteristic" (Pb-Ba-Sb-Fe-Cr) GSR particles matching those found on the suspects' hands.

This demonstrated that the unusual particles originated from barrel contents and, in one case, supported evidence of firearm cleaning after discharge.

Cleaning activity is certified by the presence of a wire bristle brush.

These cases highlight the forensic value of examining firearm barrel contents as a preventive and complementary step in GSR interpretation.

Keywords: inorganic GSR, SEM-EDS examination, GSR interpretation.



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33 - Keep It in the Family: From Mom's Back to Grandpa's Grave Are we wasting information avoiding different GSR compositions without reference samples?

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Abstract

According to the latest version of ASTM E1588 some GSR compositions are not allowed if reference samples are not available.

We present a case with many individuals involved, where the discrimination provided by distinct GSR compositions (Pb, Sb, Ba), (Pb, Sn, Si, Ca, Ba) and (Pb, Sn, Sb, Ba) allowed us to draw/understand the actions of the people involved in this scenario where a victim (the mother) was killed with two shots from the back while she was on a phone call with a friend.

According to the police investigation the son was suspect of being the author of the shots with the dad's revolver. After the crime, he would have covered his mother with a blanket and went out to the garage where he met a friend and they tried to remove a motorcycle without success.

The son then fired a third shot at the cell phone, threw it into a pool, and the friend kept the spent cartridge cases in his pockets. Together, they hid the revolver in the grandfather's grave.

When the father returned home, he found his wife covered and tried to revive her. The CSI team collected samples from the victim's hands, the father, the son, the friend and the motorcycle. The detected GSR compositions were:

Sample	GSR compositions detected											
	Pb	Sb	Ba	Pb	Sn	Si	Ca	Ba	Pb	Sn	Sb	Ba
Son						✓					✓	
Father		✓									✓	
Motorcycle		✓				✓					✓	
Friend's jacket (Pockets)		✓				✓					✓	
Victim		✓				✓					✓	
Revolver (samples collected in the lab)		✓									✓	

Although spent cartridge cases were unavailable, samples from the victim and the revolver were considered reference samples.

However, under the latest ASTM E1588, could the composition (Pb, Sn, Si, Ca, Ba) still be considered?

Keywords: ASTM E1588, particle composition, GSR, reference samples.



34 - New Approaches to Non-Destructive Forensic Analysis: FTIR and Raman with Multivariate Analysis

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Abstract

Vibrational spectroscopy is becoming an increasingly important tool in forensic science thanks to its ability to provide rapid, non-destructive chemical information with minimal sample preparation.

This presentation highlights the application of FTIR and Raman microscopy to forensic investigations, with particular emphasis on the analysis of gunshot residue (GSR).

The presentation focuses on Raman imaging combined with Multi-Curve Resolution (MCR), a powerful chemometric approach that separates complex spectral data into their individual chemical components.

Using representative forensic samples, the workflow demonstrates the identification of organic gunshot residue particles deposited on different textile substrates, including challenging matrices contaminated with dried blood.

The use of SEM stubs as a common sampling platform for both Raman microscopy and SEM-EDS is also discussed, highlighting the advantages of combining complementary analytical techniques.

The latest Thermo Scientific FTIR and Raman microscopy solutions, including the DXR3xi Raman Imaging Microscope and the Nicolet RaptIR+ FTIR Microscope, are presented.

These platforms combine high spatial resolution with advanced chemometric tools, providing a robust and user-friendly workflow for the analysis of trace evidence, counterfeit materials, narcotics, pharmaceuticals, polymers, fibers, inks, and other forensic samples.

Keywords: Forensic Science, Gunshot Residue (GSR), Raman Imaging, FTIR Microscopy, Multi-Curve Resolution (MCR)



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FIREARMS WORKSHOPS

Workshop 1 – *Observations on bullet holes in cars*

Presenter: Ing. (EUR ING) Axel MANTHEI ¹

¹ Axel MANTHEI holds an engineering degree in firearms design and ballistics. He was employed as research and development engineer with the firearms manufacturer UMAREX for 6 years. From 1988 till January 2025, he was employed as firearm examiner in the Bavarian Police Crime Laboratory in Munich, and has examined crime scenes in Europe, Asia and South America. He now operates his private firearms laboratory and is engaged in forensic training with the courses “Toolmarks on Reloaded Ammunition” and “Shooting Reconstruction”. Further on he operates his own company which produces the well-known Ammunition Database CartWinPro.

Axel MANTHEI is a distinguished member of AFTE and an accomplished target pistol shooter on an international level.

Duration: 90 minutes

Content:

The workshop focuses on findings based on a series of experiments as well as on experience gained during crime scene investigations.

It is divided into sections covering the results of test firing on car body parts, vehicle windows and car tires.

The damage to and deformation of the car body parts allow conclusions regarding both the shooting direction and the type of ammunition used. Particular attention should be paid here to the differences that arise with various types of projectile design. The behavior of projectiles at shallow and very shallow angles of impact is also presented.

Shots fired through car windows produce a distinctive pattern of evidence. In this context, a distinction must be made as to whether the damage was actually caused by projectiles from firearms or by objects kicked up by other cars. The path of the resulting glass splinters is discussed, as are the difficulties involved in determining the shooting direction when steel balls are involved.

Where there are multiple impacts in the glass, the sequence of shots can generally be identified from the pattern of marks.

Finally, the characteristics of damage to vehicle tires are discussed. Here, the elasticity of the rubber ensures that the defects are barely visible. The rotation of the tire poses challenges when determining the shooting direction. However, it is still possible to draw conclusions about the possible positions of the shooters based on the tire structure and the conditions of the vehicle.

The effects observed are described and illustrated using images and high-speed photographs.



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Workshop 2 - *ImpactA: AI-Based Shooting Angle Calculation*

Presenters: Manuel RUANO ^{1,3}, José Luis FERRANDO ^{1,2,3}, Silvia FÁBREGUES-PONS ^{2,3}

¹ Ballistics and Toolmarks Department, Criminalistics Service of the Guardia Civil, Guardia Civil General Directorate, Spain

² Department of Physics and Mathematics, Universidad de Alcalá, Spain

³ Instituto Universitario de Investigación en Ciencias Policiales (IUICP), Universidad de Alcalá, Spain

Duration: 120 minutes

Content:

The aim of this workshop is to introduce ENFSI experts to a new tool designed to support Crime Scene Investigators in the calculation of shooting impact angles.

The workshop will begin with a brief overview of the most used methods for calculating shooting impact angles, including rods and trigonometry, followed by an introduction to the guidelines for using *the ImpactA App*, which will be installed on a smartphone.

As this is intended to be a practical workshop rather than a theoretical session, participants will actively take part in the activities.

Depending on the number of attendees, participants will be divided into groups, with one smartphone available for each group.

Each group will be asked to measure the angle of impact of several single-hole bullet impacts, like those encountered at a crime scene, and record the measurements in a questionnaire.

The organizers will collect all the data and analyse the results, which will then be shared with the ENFSI community.

This exercise will help assess and validate the reliability of *the ImpactA App*.

We hope this will be an enjoyable and scientifically valuable experience, carried out in an inspiring environment and surrounded by some of the leading experts in Forensic Ballistics.



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GSR WORKSHOPS

Workshop 1 - *Does Europe need his own GSR standard?*

Presenter: *Ruediger SCHUMACHER*¹

¹ *Bundeskriminalamt, Germany.*

Duration: 90 minutes

Content:

Many EWG members are not satisfied with E1588-25 as a standard for GSR detection by SEM-EDS.

This raises the question “Do we need our own standard document?”.

In this workshop it should be explored, how a European guideline might look like and who is willing to contribute in a future project group.



Workshop 2 - *Integrated Forensic Investigation of an Officer-Involved Shooting: From Crime Scene Examination to Event Reconstruction*

Presenters: *Jose Antonio RODRIGUEZ-PASCUAL^{1,3}, Alicia DOÑA-FERNANDEZ^{2,3}, Juan Francisco SAAVEDRA-ALVAREZ¹, Tomas CASADO-CHINARRO¹, Oscar MUÑOZ-PAULA¹, Iñaki MARTÍN-BARBER¹, Daniel VICENTE AYRA¹*

¹ Ballistics Section of the Spanish Scientific Police Headquarters (National Police), Spain

² Forensic Laboratories-In Service Support LAND, INDRA System, Spain

³ University Research Institute of Police Sciences (IUICP), University of Alcalá, Madrid, Spain

Duration: 120 minutes

Content:

This workshop presents and describes the forensic investigation of an officer-involved shooting resulting from a violent confrontation between an armed suspect and two police officers in Spain. As judicial proceedings are still ongoing, all identifying information has been removed and anonymized.

The case study focuses on the forensic workflow followed from the initial crime scene examination through the subsequent laboratory assessment of evidential items.

Particular attention is given to the integration of information obtained at different stages of the investigation and its contribution to the interpretation and reconstruction of the incident.

In this workshop it will be discussed how scene findings, physical evidence and laboratory results were evaluated within a single investigative framework to support decision-making and establish a scientifically supported reconstruction of the events.

This case highlights the importance of coordination between crime scene and laboratory activities and demonstrates how the combined evaluation of forensic evidence can contribute.



POSTER SESSION

Iron among discharge residues of cartridge operated tool in case of alleged suicide

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Abstract

Iron is present among the firearm discharge residues, sometimes in great amounts when the barrel bears rust inside. The lethal effect, being similar to that resulting from the firearm, can be caused by cartridge operated tools, such as nail or rivet guns that are widely used in construction as well as captive bolt pistols utilised in the meat industry for stunning animals prior to slaughter. In such cases forensic protocols mirror those of a traditional firearm and gunshot residues investigation. Evidence is collected similarly because both utilize a cartridge containing the primer and propellant that, upon ignition, releases particles, including lead, barium, and antimony.

A disputed suicide case with a captive bolt pistol was chosen for presented.

The laboratory examinations of specimens collected from hands, face and clothing of the victim were conducted towards inorganic gunshot residue (GSR), as stated in the prosecutor's decision to seek the opinion of a forensic expert. The analysis was performed by means of scanning electron microscope and energy dispersive X-ray spectrometer (SEM-EDX) in the automatic manner. The obtained results were atypical for routine GSR analysis, and so they called for extensive experience and a nuanced understanding of the subject. The interpretation of the findings was challenging as none of the spectra of detected particles was without prevailing amounts of iron. The issued expert's opinion with its final conclusion was based both on GSR identification as well as the case files including detailed information on the construction and action of the cartridge operated tool, which was found by the body of the deceased and later examined by the firearms expert.

The presented case is an illustration of a sustained need for the forensic expert to be vigilant as far as the interpretation of the analytical findings towards GSR and related residue examinations is concerned.

Keywords: forensic analysis, inorganic gunshot residue (GSR), residue of cartridge operated tools, SEM-EDX automated analysis of particles.