ABOUT THE EDUCATION OF FORENSIC EXPERTS IN CURRENT CONDITIONS



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Abstract In the contemporary world, marked by intense armed conflicts and rapid technological development, forensic experts have become a central pillar of the administration of justice and the promotion of public trust in judicial acts. This article examines the urgent need to modernize forensic expert training in order to meet new professional and legal challenges, in particular the rigorous standards required for the collection, preservation and analysis of so-called "battlefield evidence." Contemporary forensic education must now integrate emerging fields such as digital forensics, nuclear forensics, and aerospace (UAV-based) forensics, together with the use of artificial intelligence for the identification of victims and the analysis of advanced weaponry. Given the heavy workloads and hazardous operating conditions faced by experts working in or near conflict zones, continuous professional development — at least 40 hours annually — is presented as essential for maintaining impartiality, objectivity and scientific rigor. The article further argues that international cooperation, through programs such as the European Training Center of Active Forensic Sciences (ETAF) and mechanisms coordinated by Eurojust, is indispensable for aligning national methodologies with global standards, including the UN Minnesota Protocol, the Berkeley Protocol, and INTERPOL's Disaster Victim Identification guidelines. Using a comparative legal analysis and case studies drawn from the war in Ukraine, the authors identify the principal technological, organizational and legal obstacles to producing admissible evidence under extreme conditions. The authors conclude that standardizing forensic expert training according to international requirements, including the Rome Statute [8], is essential for evidence gathered in conflict zones to be admissible before both national courts and the International Criminal Court, and propose concrete measures for reforming national training systems accordingly.

Key-words: forensic science; forensic expert training; digital forensics; nuclear forensics; aerospace forensics; artificial intelligence; victim identification; battlefield evidence; Minnesota Protocol; Rome Statute; International Criminal Court; international cooperation.

Introduction The escalation of large-scale armed conflicts — and above all the war in Ukraine, which has produced the highest concentration of documented war crimes investigations in Europe since the Nuremberg era — has placed immense and unprecedented pressure on judicial experts. These professionals are increasingly required to operate in active combat zones, amid unexploded ordnance, contested territory and the physical destruction of the very infrastructure (morgues, laboratories, archives) that forensic work traditionally depends on, while simultaneously managing a volume of cases that vastly exceeds the capacity of conventional forensic institutions built for peacetime caseloads. This structural shift — from isolated, individually processed cases to mass-casualty events requiring simultaneous identification of hundreds or thousands of victims — has driven the emergence of entirely new forensic specialties that did not exist, or existed only marginally, in national training curricula a decade ago. Digital forensics has become indispensable for authenticating video, satellite and metadata evidence in an environment saturated with manipulated or fabricated material; nuclear forensics has moved from a theoretical niche to an operational necessity following direct attacks on nuclear facilities; and AI-driven victim identification now allows experts to correlate ante-mortem records (dental charts, medical histories, DNA samples submitted by families) with post-mortem findings at a scale and speed no human team could achieve manually [9]. Recognizing that no single national system can absorb this technological and methodological burden alone, international organizations such as the European Training Center of Active Forensic Sciences (ETAF) and Eurojust have taken on an increasingly active coordinating role, not merely disseminating best practices but actively working to harmonize investigative methods, terminology and evidentiary thresholds across dozens of jurisdictions, so that material collected by one national team can be seamlessly used, cross-referenced and admitted by another. [19] This harmonization is not a matter of administrative convenience: it is a legal precondition. For evidence gathered on the battlefield — often under fire, without the controlled conditions of a conventional crime scene, and frequently by first responders or military personnel rather than trained forensic teams — to retain any legal validity, the experts overseeing its collection, packaging and chain of custody must be rigorously and demonstrably trained in internationally recognized standards, chief among them the UN Minnesota Protocol [18]. Only such standardized training can protect the integrity of information gathered in chaotic, high-pressure settings where a single procedural error — a broken chain of custody, an undocumented site disturbance, an unverified source — can be enough to have an entire body of evidence excluded. Viewed in this light, the continuous professional development of forensic experts is not a peripheral administrative requirement but a foundational pillar supporting the entire architecture of international accountability: without experts trained to a common, verifiable standard, neither the International Criminal Court (ICC) nor the framework established by the Rome Statute can translate battlefield atrocities into evidence capable of surviving judicial scrutiny and, ultimately, of holding perpetrators of war crimes and crimes against humanity accountable.

Problem Statement Despite the growing demand for forensic evidence from conflict zones, national systems of forensic expert training in many countries, including the Republic of Moldova, have not kept pace with these developments. Several interrelated problems can be identified: (1) the absence of specialized training in emerging forensic disciplines such as digital forensics, nuclear forensics and aerospace (UAV-based) forensics; (2) insufficient integration of artificial intelligence tools for victim identification and evidence analysis into standard practice; (3) the lack of a unified, mandatory framework of continuous professional development for forensic experts; and (4) limited institutional capacity for international cooperation and harmonization of methodologies with instruments such as the Minnesota Protocol, the Berkeley Protocol and the Rome Statute. These gaps risk producing forensic evidence that, however scientifically sound, fails to meet the procedural and methodological requirements for admissibility before international tribunals, thereby undermining accountability for war crimes and crimes against humanity.

Aim and Methods of the Study The primary aim of this article is to analyze the necessity of adapting forensic training to modern global realities, specifically focusing on the integration of emerging technologies like digital forensics and artificial intelligence. It also explores how standardized methodologies and international cooperation ensure that evidence gathered in hazardous zones remains admissible in national and international courts. This research is based on a comprehensive review of international legal frameworks, including the Rome Statute and the Minnesota Protocol, alongside reports from bodies like Eurojust, ETAF, and the United Nations [4]. The study employs a comparative analysis of forensic methods and incorporates case studies from active conflict zones to assess the practical challenges of securing battlefield evidence. By using an interdisciplinary approach, the authors examine the role of UAVs, AI, and digital forensics in modern investigative procedures.

Materials and Methods The empirical and normative basis of this research includes: international legal instruments (the Rome Statute of the International Criminal Court, 1998; the UN Minnesota Protocol on the Investigation of Potentially Unlawful Death, 2017; the Berkeley Protocol on Digital Open Source Investigations, 2020; the Istanbul Protocol, 2022); institutional guidelines (INTERPOL's Disaster Victim Identification (DVI) Guide, Eurojust's guidelines on Joint Investigative Teams); training frameworks and pilot programs published by the European Training Center of Active Forensic Sciences (ETAF); and documented case studies from the conflict in Ukraine, including the aerial mapping of destruction in the Northern Saltivka district of Kharkiv, the assessment of nuclear-related risks at the Kharkiv Institute of Physics and Technology and the Zaporizhzhia Nuclear Power Plant, and the operation of Ukraine's citizen-participation platform “Warcrimes.” The methodology combines qualitative comparative legal analysis with a structured review of the technological and organizational components of forensic investigation in conflict settings, allowing the identification of both good practices and systemic gaps in current training models.

Results and Analysis The current global security landscape, significantly redefined by the aggression against Ukraine, has forced a paradigm shift in the administration of justice: the transition from traditional reactive forensics to an integrated "forensic emergency" model. Forensics is no longer just a series of technical steps; it is now a strategic component of international security capable of generating irrefutable evidence under extreme pressure. The core challenge is not just data collection, but validation within an information ecosystem often polluted by disinformation. This article examines a strategy to reform expert training, making digital technology and rigorous international protocols the new operational standards. This evolution is the only way to ensure that justice transcends national borders, transforming atrocities into evidence files capable of withstanding the requirements of the ICC.

Discussion Technological innovation is redefining the concept of "electronic evidence," acting as a force multiplier that allows access to evidence in areas where physical presence would be too dangerous.

·**AI and Biomedical Identification:** AI algorithms now accelerate the identification of victims by automatically correlating ante-mortem and post-mortem data with high scientific precision. [10]

·**Aerospace Forensics (UAVs):** Drones and multispectral imaging have become essential tools for "necrosearch"—the aerial detection of hidden graves. For example, mapping the destruction in Kharkiv's Northern Saltivka district provides a "legally admissible" perspective on intentional attacks against civilians. [1,14]

·**Digital Forensics and OSINT:** The Berkeley Protocol [16] sets the minimum standards for collecting digital evidence from social media or satellites, ensuring data remains untampered and serving as a barrier against disinformation.

·**Nuclear Forensics:** Attacks on facilities like the Kharkiv Institute of Physics and Technology and the Zaporizhzhia plant demonstrate the need for nuclear forensics to trace radioactive materials and document acts of nuclear terrorism. [7, 20]

Standardizing methodologies is an operational imperative to ensure interoperability between national and international services. Any failure to follow established protocols compromises the validity of evidence before the ICC [17,22]. The efficiency of an investigation depends on the synergy of two "gold standards":

1. **INTERPOL's DVI Protocol**, which manages the logistical flow for identifying victims.

2. **The UN Minnesota Protocol**, the ultimate standard for investigating potentially unlawful deaths and mass graves. Effective management also requires a unified numbering system for victims, missing persons, and refugees, alongside sophisticated DNA data management to link displaced persons with samples collected from conflict zones [6,24]. The pilot training model conducted by the European Training Center of Active Forensic Sciences (ETAF) represents the future of legal assistance, focusing on a "Training of Trainers" approach and ensuring impartiality through international observers.

The ultimate goal of any investigation is to hold decision-makers accountable. Joint Investigative Teams (JITs) involving multiple nations under the auspices of Eurojust

and the ICC are fundamental to maintaining the "chain of custody" [6]. While platforms like Ukraine's "Warcrimes" [2,15,21] facilitate participatory forensics, data collected by citizens must pass through rigorous technical-legal filters to become "legally admissible" evidence and maintain the credibility of the judicial process [3,23].

These evolving challenges underscore the need for a modern approach to the education and professional development of forensic experts.

A modernized competency map requires an equally modernized institutional design. In practice, this means that forensic education should be organized in layers rather than as a single pre-service program.

The first layer is foundational education. Every forensic expert, regardless of specialization, should receive a common core in scientific method, legal standards of proof, ethics and impartiality, documentation, chain of custody, report writing, testimony, quality management, and rights-based investigation. The common core should also include basic digital evidence handling, metadata awareness, information security, trauma-informed engagement, and the logic of international cooperation. This does not eliminate specialization. It ensures that the specialized path rests on a shared professional language. The lesson of recent atrocity investigations is unmistakable: institutional failure often occurs not because one specialist lacks knowledge, but because multiple specialists do not understand how their evidentiary contributions connect.

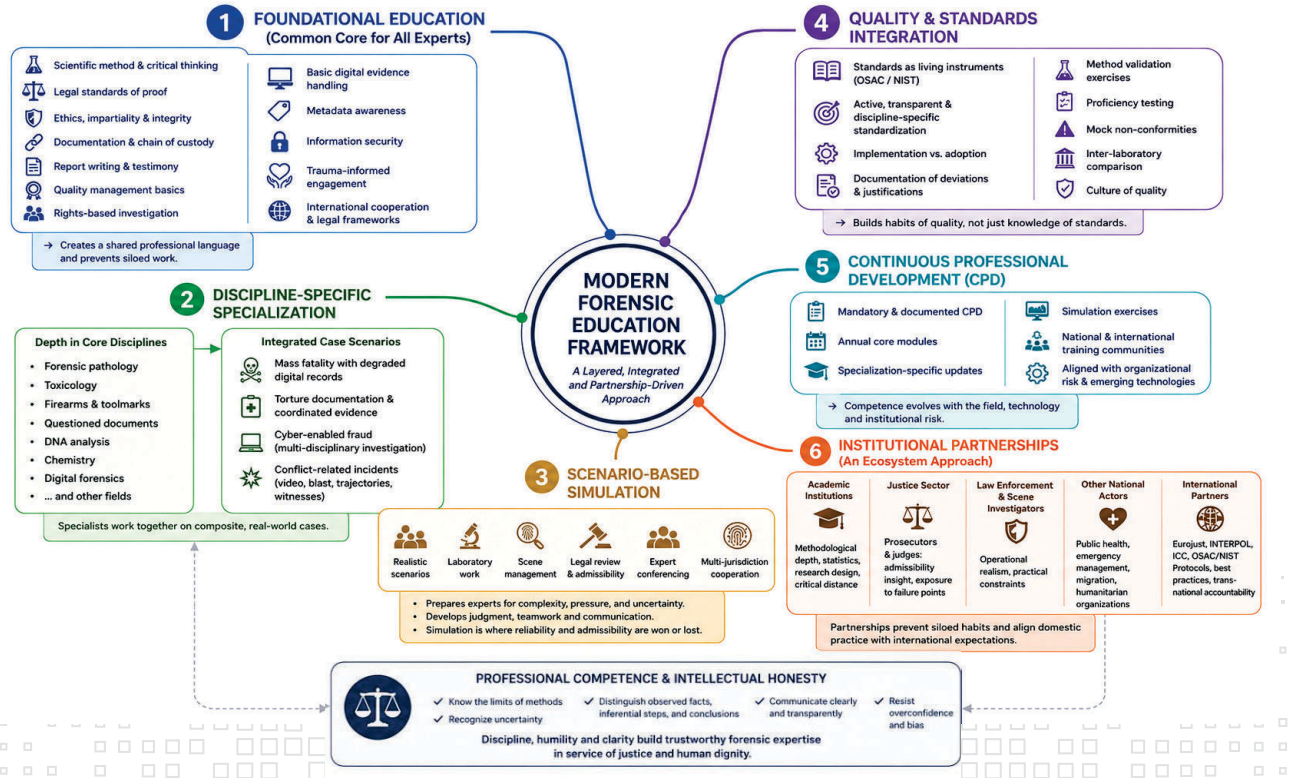
The second layer is discipline-specific specialization. Here, laboratories and training institutions should continue to cultivate depth in pathology, toxicology, firearms, questioned documents, DNA, chemistry, digital forensics, and other fields. However, these tracks must no longer be legally or operationally isolated from one another. Specialists should periodically work through common case scenarios: a mass fatality incident with degraded digital records; a suspected torture case requiring coordinated medical and evidentiary documentation; a cyber-enabled fraud investigation with phone extraction, document examination, and financial analysis; or a conflict-related incident involving video, trajectories, blast damage, and witness statements. In short, curriculum design should reflect the composite reality of casework.

The third layer is scenario-based simulation. This is where many systems remain weak. Standard lectures are not enough to prepare experts for fragmented remains, chaotic scenes, multilingual cooperation, damaged metadata, intimidated witnesses, or media pressure. Eurojust's experience with workshops and training sessions on core international crimes is instructive here. Its materials show the value of focused training on witness statements, conflict-related sexual violence, open-source information, legal aspects, and practical case-building for practitioners from multiple jurisdictions. Educational institutions should adapt this model domestically through simulations that combine laboratory work, scene management, legal review, and expert conferencing. Well-designed simulations test judgment under pressure, which is often where admissibility and reliability are won or lost (Eurojust, n.d.-c). [4]

The following flowchart captures the educational logic proposed h

Figure 1. The logical process of education

The fourth layer is quality and standards integration. NIST's OSAC work is valuable not only because it produces standards, but because it shows that standardization must be active, transparent, and discipline-specific. Training institutions should therefore teach standards as living instruments. Students and practitioners should learn how standards are developed, how implementation differs from mere adoption, and how deviations should be documented and justified. Where possible, laboratory training should be linked to proficiency testing, mock non-conformities, method



validation exercises, and inter-laboratory comparison. Otherwise, experts may acquire the language of quality without the habits of quality (NIST, 2026). [12]

The fifth layer is continuous professional development. A contemporary forensic institution should not assume that competence acquired once will remain sufficient. INTERPOL's DVI working structures, Eurojust's evolving guidance, and OSAC's registry illustrate a broader point: the field changes institutionally as well as technologically. CPD should therefore be mandatory, documented, and aligned with organizational risk. A practical model would combine annual general modules, specialization-specific updates, simulation exercises, and participation in national or international training communities.

Institutional partnerships are also essential. Universities bring methodological depth, statistics, research design, and critical distance. Prosecutors and judges contribute admissibility insight and exposure to evidentiary failure points. Police and scene investigators bring operational realism. Public health, emergency management, migration authorities, and humanitarian actors become relevant in DVI, torture documentation, or missing-persons work. Cross-border institutions such as Eurojust, INTERPOL, and the ICC are not merely external consumers of expertise; they are educational partners whose protocols expose national systems to the demands of transnational accountability. Curriculum reform that excludes these actors will tend to reproduce siloed habits (Eurojust, n.d.-c; INTERPOL, 2023; NIST, 2026). [4,9,12]

Finally, a mature institutional design must reward intellectual honesty. The best forensic education does not produce overconfident experts. It produces disciplined experts who know the limits of their methods, can articulate uncertainty without collapsing into vagueness, and can distinguish observed facts, inferential steps, and evaluative conclusions. That style of professional communication is indispensable in an era of public polarization, synthetic media, and increasingly adversarial challenges to science.

Yet education alone cannot guarantee high-quality forensic practice unless it is accompanied by effective strategies for managing emerging risks.

A stronger educational model must also confront risk openly. The first risk is technological overclaiming. New tools can create institutional excitement out of proportion to their validated performance. AI-assisted analysis is a prime example. It can accelerate triage, search, clustering, and anomaly detection, but it can also reproduce bias, misclassify novel material, conceal false positives behind opaque scores, or tempt organizations into replacing expert review with pseudo-automation. Forensic curricula should therefore teach AI in the same way they teach any other method: through validation, limitations, documentation, and challenge. The relevant standard is not whether a tool is fashionable, but whether the reasoning it supports is scientifically and legally defensible (Nayerifard et al., 2023; Mukhopadhyay et al., 2024). [11,13]

The second risk is contamination of evidentiary chains. In digital investigations, contamination may occur through re-encoding, stripping metadata, preserving only screenshots, failing to capture source URLs or timestamps, or mixing evidentiary copies with working copies. In physical evidence management, contamination arises through poor packaging, degraded recovery, incomplete scene logs, or lack of contamination-control measures in mass-fatality or CBRN settings. Educationally, contamination should be taught not as a technical mishap but as a systems failure. Once that perspective is adopted, training naturally expands from “how to collect” to “how to preserve the legal biography of evidence” (OHCHR, 2017; WIRED, 2022; INTERPOL, 2023). [9,18,21]

The third risk is fragmentation of responsibility. In complex cases, no single actor sees the whole picture. Scene teams may assume laboratories will correct documentation gaps; laboratories may assume prosecutors will repair legal framing; prosecutors may assume specialists understand contextual elements; NGOs may assume official investigators will preserve what they have gathered. Such assumptions are dangerous. The response should be matrix training: experts learn enough about adjacent roles to recognize when a gap will become fatal later in the evidentiary chain (Eurojust, 2022; Eurojust, n.d.-c). [4]

The fourth risk is ethical fatigue. Exposure to graphic violence, mass-fatality scenes, missing-persons cases, torture allegations, or highly polarized public narratives can erode judgment over time. INTERPOL's DVI materials are notable for including occupational care and family-support dimensions. That should be taken seriously as an educational point. Professional resilience is not sentimental adjunct material. It directly affects accuracy, impartiality, and retention of experienced personnel. Curricula and institutional CPD frameworks should therefore include psychological preparedness, peer debriefing, and structured referral systems (INTERPOL, 2023). [9]

The fifth risk is legal mismatch. A forensic system may adopt technically impressive methods that its courts, legislation, disclosure rules, or privacy frameworks are not yet ready to receive. This is a recurrent problem in digital investigations. If institutions do not align educational reform with procedural law, data-protection requirements, and judicial understanding, capability grows faster than admissibility. The result is frustration, inconsistency, and unnecessary challenge in court. Hence reform must be cross-professional: experts, judges, prosecutors, and policymakers need partially shared learning ecosystems (Eurojust, 2024; NIST, 2026). [5,12]



Conclusions and Practical Recommendations The pillars of strategic reform involve adapting forensic science to new geopolitical realities is fundamental to the rule of law in the 21st century. To ensure justice, three pillars of strategic reform are essential:

1. **Institutionalizing Aerospace and Digital Forensics**: Adopting UAVs and OSINT analysis as state standards, rather than ad-hoc tools.

2. **Universalizing the Minnesota Protocol:** Implementing it in national legislation as a mandatory norm for investigating war crimes.

3. **Strengthening Interoperability Networks:** Creating a global data management system for DNA, odontology, and digital evidence to allow for the instantaneous exchange of information between international organizations.

In addition, the authors recommend establishing a mandatory minimum of 40 hours of continuous professional development per year for practicing forensic experts, expanding participation in international programs such as ETAF, and formally incorporating international observers into national training and certification processes to guarantee impartiality. Justice for the victims of current armed conflicts depends, ultimately, on the rigor of forensic science applied with a coherent strategic vision.

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