Secure Systems Design and Technology Development. Veliko Tarnovo, Bulgaria
Proceedings of the International Scientific Conference, 2026. Volume I, 173-180

An Integrated Concept for the Protection of Photographic and Electronic Equipment during Crime Scene Investigation Using a Risk-Oriented Protocol

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***Abstract*—Forensic photography is performed in uncontrolled environments where photographic and other devices are exposed to both direct impacts (blood and body fluids, dust/soot, chemical residues, water, mechanical impacts) and indirect risks, turning the equipment into a reservoir and a means of transferring traces and contamination between objects, different areas and subsequent examinations. Typically, personal protective equipment (PPE) is considered as a barrier to protect personnel, but the same barrier logic can be symmetrically applied to equipment through different layers of protective coatings, touch interface control, zoning (HOT/WARM/COLD), role separation, sealing before transport and staged decontamination. This report proposes a protocol that combines physical contamination control with digital integrity control (metadata, controlled transfer, hashing) so that images and devices are processed in a defensible manner within the framework of quality management.**

Keywords—crime scene investigation, equipment protection, forensic photography, personal protective equipment.

I. INTRODUCTION

Photographic documentation is a fundamental mechanism for capturing traces and ensuring subsequent verifiability of what is described in the protocols for inspection of crime scenes, measurements and reconstruction. The expansion of photographic practices with 360° panoramas, photogrammetry, and multispectral studies using alternative light sources (ALS), drones and portable 3D scanners increases the number of devices that are introduced and removed from potentially hazardous and contaminated environments.

There are two interrelated groups of risks. First, uncontrolled exposure to biological fluids, unknown powders, soot, solutions and corrosive residues can lead to damage to optical coatings, rubber seals, adhesive joints and electrical connectors, which can compromise the performance of the equipment. Second, the equipment (especially the camera and accessories) is subject to repeated handling by the operator and can thus come into contact with surfaces carrying biological material, fibres or particles. Without proper control, the devices can carry traces between different areas, in packing areas, in official police vehicle, or when moving to subsequent examination of evidence. In private cases, the camera itself can become a real source of unknown deoxyribonucleic acid (DNA).

The purpose of this report is protection of the reliability and operational readiness of equipment and protection of evidentiary integrity by minimizing cross-contamination. This paper contributes a risk-oriented protocol that applies personal protective equipment (PPE) principles - barrier protection, touch-interface control, procedural standardization, and traceability - to photographic and electronic equipment used for Crime Scene Investigation (CSI).

Original contributions of this paper are:

- A risk-oriented protocol that symmetrically applies PPE principles to photographic and electronic CSI equipment.
- A combined zoning-and-state model for equipment (COLD/WARM/HOT; CLEAN, IN-USE-HOT, QUARANTINE,

Online ISSN 3044-7771
https://doi.org/10.68302/std2026.vol1.117

DECONTAMINATED) linked to role separation.

- Touchpoint-based interface control with observable glove-change triggers to reduce cross-contamination during imaging.
- An integrated workflow that couples physical contamination control with digital integrity controls (controlled transfer, hashing, and audit logs).

A. Related Research and Good Practices

Experimental studies in forensic science have shown that practitioners can transfer DNA to simulated scenes, and the use of protective clothing reduces the potential for contamination, which could serve as a basis for studying barrier-oriented crime scene examination practices [1].

Regulatory and best practices in DNA contamination control emphasize preventive measures to limit access, zoning, route control, routine glove changes, and clear separation of sterile supplies/equipment from seized objects during transport [2]. This applies to cameras, tripods, and lighting, which remain implicitly included in many standard operating procedures (SOPs) but are rarely formalized as a set of risky touchpoints and equipment conditions.

Additionally, good practices in digital forensics and digital evidence management emphasize documented workflows and integrity checks (e.g., hash functions) for demonstrable file integrity. Therefore, a defensible imaging workflow requires both physical contamination control and digital integrity control [3, 4].

B. Regulatory and Methodological Framework

In the European Union (EU) context, PPE should comply with the requirements of Regulation (EU) 2016/425 on essential health and safety requirements, conformity assessment and instructions for use [5]. For forensic examinations and work, European Network of Forensic Science Institutes (ENFSI) guidance documents define functional areas and infrastructure (material storage, changing room, evidence area) supporting the controlled circulation of equipment around the scene [6]. DNA contamination guidelines (e.g. FSR-GUI-0016) frame controls as a combination of prevention and detection through appropriate PPE, restricted access and effective separation of equipment/consumables from seized objects during transport and processing [2]. The standard of International Organization for Standardization (ISO) 18385 defines requirements for products used for the collection, packaging and storage of biological material, in order to minimize contamination with human DNA. Although the standard is aimed at single-use products, its logic supports similar approaches for reusable devices - standardized interfaces, limited uncontrolled contact, and documented cleaning steps [7]. Operationally, the sequences for donning/doffing PPE and the management of contaminated surfaces are well described in health protocols and can be adapted to forensic crime scene examinations, taking into account the specific risks of the particular case [8].

II. MATERIALS AND METHODS

A. PPE Categories And Controlled Donning/Doffing Relative To Electronic Equipment

For the purposes of scene documentation, PPE should be understood as a layered system rather than as a single garment. Basic hand protection is provided by disposable nitrile gloves, which are the primary barrier against direct transfer of biological material and particulate contamination. Respiratory protection ranges from simple masks used for nuisance dust control to filtering facepiece class 2/filtering facepiece class 3 (FFP2/FFP3) respirators when aerosols, soot, or unknown powders may be present. Eye and face protection includes goggles or face shields when splashes, flying particles, or intensive alternate light source/ultraviolet (ALS/UV) work are expected. Body protection may include disposable coveralls, sleeves or aprons, while footwear protection includes dedicated work shoes and disposable overshoes where transfer from the floor surface is a realistic risk [5], [2], [8].

From the standpoint of photographic and electronic equipment, not all PPE elements have the same operational significance. Gloves directly affect camera handling, button sensitivity and touchpoint transfer, masks and respirators influence communication and the risk of exhaled contamination near optical devices. Goggles and face shields affect viewfinder use and the handling of optical filters, coveralls and sleeves affect the risk of brushing against tripods, light stands and evidence markers. This functional distinction is useful because it links PPE selection not only to worker protection, but also to the quality and cleanliness of device operation within the evidential environment [6], [2], [4].

A controlled donning sequence is necessary because the first uncontrolled contact often occurs before the team enters the HOT zone. As a rule, inner PPE elements that are intended to remain with the operator for the whole task should be donned first, followed by body protection, footwear protection, respiratory protection, eye protection, and finally the outer glove layer. The outermost glove layer should be the last element applied [8].

Electronic equipment should not be handled at every stage of donning. The recommended approach is to divide contact into three moments - pre-donning preparation of the kit in a CLEAN condition, a final functional check after the main PPE ensemble has been donned but before the outer gloves have touched contaminated surroundings and operational handling only after entry under the selected control level. In practice, batteries, memory cards, lens mounting, time synchronization and cover placement should be completed in COLD zone before the outer gloves are exposed. After that point, the equipment is treated as a controlled clean object whose status must be preserved until scene work begins.

The handling of electronic equipment can be organized into distinct operational stages. Stage 1 is pre-entry

preparation in COLD, where devices are assembled, labelled, synchronized and protected. Stage 2 is controlled transition through the access point, where only essential confirmation actions are allowed. Stage 3 is active use in HOT, where the operator should touch only the minimal exposed interface and avoid unnecessary adjustment cycles. Stage 4 is WARM-zone stabilization, where covers, outer bags and visible contamination status are managed. Stage 5 is post-scene handling in COLD, where media transfer, logging and secondary decontamination take place. This stage model helps maintain a consistent relation between PPE status, zone status and equipment status.

Such staging also clarifies when glove changes are required. For example, gloves used to move markers, touch doors, assist with object manipulation or contact wet/dirty surfaces should not be used for detailed manipulation of the camera interface without replacement. Conversely, when a camera-only glove policy is adopted, the operator can preserve a more stable clean-touch condition for image acquisition while the evidence handler performs higher-risk contact tasks. This reduces ambiguity in the field and strengthens the procedural defensibility of the workflow [2], [7].

The sequence for removing PPE is as important as the sequence for donning it because contaminated outer layers can transfer material back to the operator, the vehicle and the equipment if they are removed in an uncontrolled order. As a general principle, the most contaminated external elements are removed first in the transition area, while the inner layers that protect the operator during the final handling stages are removed later. Outer gloves used in HOT should therefore be removed or exchanged before touching clean storage areas, digital work surfaces, keyboards, packaging materials or the inner compartments of transport cases [2], [8].

After leaving HOT, the device should first be isolated or quarantined before progressive doffing continues. This prevents the common error of placing a possibly contaminated camera or tripod into a nominally clean area while the operator is still partially contaminated. Only after the device has been bagged or stabilized should the sequence proceed through removal of disposable sleeves or coveralls, eye/face protection and respirators in accordance with local safety rules, with hand hygiene or glove replacement inserted whenever the procedure crosses from dirty-touch to clean-touch actions. The key methodological point is that doffing and equipment handling should be read as one integrated chain rather than as two separate tasks.

B. Threat Model and Design Requirements

Hazards are grouped as biological (blood, body fluids, decomposition), dust particles (dust, soot, fingerprint powders, fibres), chemical (solvents, acids/bases, synthesis lab residues, scene cleaning agents), physical-mechanical (impacts, water, temperature differences, vibrations), optical (ALS/UV/laser sources, glare and risk of filter/sensor degradation). Each group generates simultaneously a risk to personnel, a risk to evidentiary integrity through transfer/contamination and a risk to the functionality of the equipment through corrosion, dusting or damage.

Each hazard group should be assessed not only by its direct effect on personnel but also by the type of secondary contamination it can generate on equipment surfaces. Biological contamination has the highest evidential sensitivity because even minimal uncontrolled contact may later be interpreted as scene-derived material. Dust, soot, and powder hazards are especially relevant because they persist in recesses, controls, and textile components and are easily redistributed during packing, transport, and later reuse of the equipment.

The most common pathways occur through repeated touch points such as the shutter release, command dials, rear display, viewfinder/eyecups, lens barrel/focus ring, quick release plate, strap/harness, and tripod controls. Paths are activated when transitioning between “dirty” activities (marking, moving objects, surface testing) and “clean” activities such as packaging, filling out protocols, and working with files. Without rules for changing gloves and interface management, the risk of trace transfer is high.

Before entering the scene, the team should mark the specific parts of the equipment that will be touched during work. For the camera, these usually include the shutter release, command dials, rear screen, memory-card door, battery compartment, grip, and lens barrel; for the tripod, the leg locks, centre column, and quick-release plate; for the flash or ALS device, the control buttons and mounting points; for the tablet, the screen, case edges, and ports; and for the transport case, the handle, latches, and inner compartments. Each of these points should be assigned to one of three categories - surfaces that may be touched with clean gloves, surfaces that may be touched only after glove change, and surfaces that must remain protected and should not be handled inside the HOT zone unless strictly necessary. In this way, contamination control is linked to real manipulations rather than to general warnings. The map also makes it easier to justify, document, and later explain why certain covers were applied, why gloves had to be changed at specific moments, and why some operations were restricted to the WARM or COLD zone.

The criteria used to evaluate and select PPE and equipment-protection measures during scene work are:

- conducting a risk assessment to select an appropriate barrier with sufficient resistance to the identified hazards;
- operational compatibility (PPE must enable safe work and ergonomics for operating the camera and optics);
- possibility of decontamination and material compatibility (cleaning agents must not damage coatings/seals);
- traceability and auditability (logs, labelling of equipment states) - information must be sufficient to reproduce the process;

- evidence-friendly materials - covers/adhesives must not shed fibres and must not leave residues that could be interpreted as traces.

Taken together, these criteria form a practical selection matrix rather than a purely descriptive list. In field deployment, the team should be able to justify why a given barrier was chosen, why another material was rejected, and whether the selected solution prioritizes operator dexterity, contamination control, equipment preservation, or a balanced combination of the three. This makes the protocol auditable and links equipment protection measures directly to the logic of risk assessment already used for PPE selection.

C. Risk Assessment and Control Levels

To improve consistency and reproducibility, the qualitative assessment is operationalized with simple quantitative indicators. In Table 1, Severity (S) and likelihood (L) are scored on ordinal 1–5 scales for both occupational risk and evidentiary (cross-contamination) risk.

TABLE 1. ORDINAL SCORING SCALES USED IN THE RISK ASSESSMENT.

Score	Severity (S) – example interpretation	Likelihood (L) – example interpretation
1	Negligible exposure, no visible contamination; minimal contact surfaces	Rare, unlikely in this scene context
2	Minor localized exposure, limited residues, short contact	Unlikely but plausible
3	Moderate exposure, repeated handling, detectable residues or dust/soot	Possible under normal operations
4	High exposure, wet biofluids/powders, frequent contact and handling	Likely, expected during task
5	Very high exposure, unknown/highly hazardous residues, sustained contact or aerosolization	Almost certain, multiple triggers present

Risk scores are computed as:

$$R_{occ} = S_{occ} * L_{occ}, \quad (1)$$

$$R_{evid} = S_{evid} * L_{evid}, \quad (2)$$

and the control level is determined by

$$R = max(R_{occ}, R_{evid}). \quad (3)$$

A practical thresholding scheme is L1 ($R \leq 6$), L2 ($8 \leq R \leq 12$), and L3 ($R \geq 15$), with escalation when unknown substances are suspected.

Field solutions require a rapid method. A two-axis assessment in Table 2 is proposed - severity and probability are assessed for occupational risk and evidentiary risk, with the higher score determining the level of control. Levels L1–L3 are tailored to the reality of forensic teams without a dedicated hazardous materials (HazMat) resource, but allow for escalation when unknown substances are suspected.

TABLE 2 RISK-BASED CONTROL LEVELS

Level	Typical environment	PPE (personnel)	Equipment package	Key rules
L1	Low bio/dust risk, indoor areas with no visible contamination	Gloves (nitrile), shoe covers as needed, mask when dust is present	Basic protective kit – camera cover, UV/clear filter, dedicated clean wipes	Change gloves when transitioning to camera handling so that the equipment remains in a "clean state"
L2	Moderate risk: localized blood/bio fluids, dust/soot, fingerprint powder	Double gloves; FFP2/3 respirator when aerosols are possible, protective goggles	Layered barrier package – disposable covers for grip/display, protective bags for accessories, dedicated straps	HOT/WARM/ COLD, separate camera operator from evidence handler, controlled touchpoints
L3	High/unknown risk: decomposition, unknown powders, chemical residues	Extended PPE according to risk, mandatory zoning and supervised doffing	Maximum barrier – full camera/lens coverage, sealed transport containers, segregated batteries/cards	Staged decontamination, prohibition on opening cases in the HOT zone, and documentation of every manipulation

The selected level is documented in the crime scene report. Where feasible, engineering and organizational measures (ventilation, restricted access, controlled movement trajectory) are applied before increasing protection through PPE.

The assessment should remain dynamic throughout the inspection. Escalation is required when the team encounters previously unknown powders, wider biological spread than initially visible, wet surfaces, active cleaning chemicals, or the need for close-range imaging that increases contact risk. De-escalation is possible only after the scene sector has been re-evaluated and the rationale has been recorded. In this way, control level becomes a managed operational variable rather than a one-time label assigned at the start of the examination.

D. Zoning, Roles, Equipment States and Separation During Transport

Zoning as shown on Fig.1 aims to reduce uncontrolled movement and the transfer of trace material:

- COLD includes a command area and a changing area where devices are prepared and settings are checked;
- WARM serves as a controlled transition zone with waste and decontamination points;

- HOT is the active scene area. Entry/exit points are minimized and a record is kept of persons and equipment passing through them [2,7].

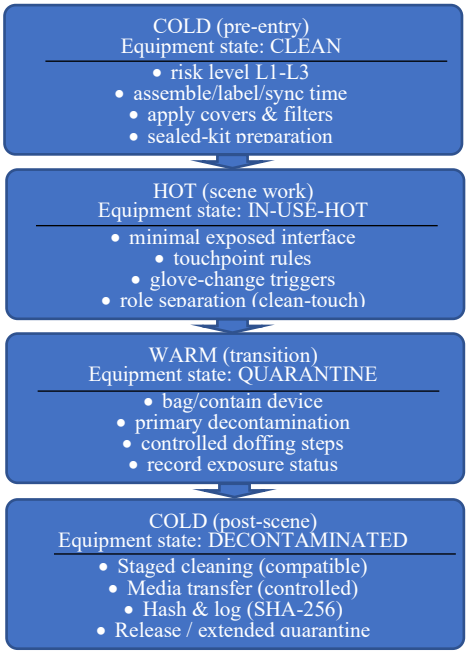

Fig. 1. Operational stages.

The protocol recommends operational role separation - a camera/scanner operator ("clean-touch" role) to minimize contact with items/traces, and an evidence handler ("dirty-touch" role). Equipment is treated as being in one of the following states - CLEAN (prepared/covered), IN-USE-HOT (used in HOT), QUARANTINE (for transport to decontamination), DECONTAMINATED (restored for COLD). All transitions between zones, operational phases, and equipment states should be documented in the crime scene inspection report.

When various reasons do not permit two separate experts, the same person may alternate between the roles only under explicit transition rules - a pause in activity, glove change, confirmation that no seized object is being handled simultaneously, and recording of the equipment state before the next action. This fallback rule is important for small field teams because it preserves the logic of separation even when personnel resources are limited, and it prevents the protocol from becoming impractical outside large forensic units.

A common weakness is the linking of different environments via service vehicles. Separation into a clean and a dirty container is recommended - CLEAN contains unopened consumables and covered devices, whereas DIRTY contains seized items and used equipment pending decontamination. Transfer between compartments is prohibited without decontamination step [2].

E. Equipment Protection Design

Protection is implemented as a layered system - an outer cover, local disposable interfaces for high-frequency touchpoints (grip, buttons, display), and an internal clean zone for batteries/cards. The goal is to reduce the surface area of uncontrolled contact and to facilitate replacement of the most contaminated layer without interrupting operations.

The layered approach is scientifically useful the outer layer receives the highest burden and can be removed or replaced without exposing the underlying controls, while local interface covers confine contamination to the limited surfaces actually touched during image acquisition. This reduces the decontamination burden, shortens recovery time after scene work, and makes it easier to explain which parts of the device were potentially exposed and which parts remained protected throughout the operation.

Covers must be impermeable to bio fluids at a level consistent with L2–L3 while also being low-lint. Smooth materials that do not shed fibres and do not crumble under friction are recommended. In dust/soot environments, it is critical to limit openings around the lens mount and rings and to use a protective (clear/UV) filter to protect the front element.

One of the most effective yet underestimated controls is glove management. At L2–L3, the use of two glove layers (inner + outer) with frequent replacement of the outer layer is recommended. Practical triggers for glove change include touching an item/surface in HOT zone, using markers/scales, contact with wet/sticky areas, transitioning to packaging/media handling, and before touching the main camera touchpoints (shutter release, dials, display). A camera-only outer-glove concept is also possible, where the outer gloves are used only to operate the camera and are replaced when leaving HOT zone.

To make this rule operational, glove-change events should be tied to clearly observable triggers rather than left to individual judgment alone. The protocol therefore benefits from predefined change points before camera activation, after evidence contact, after marking or measuring, before touching batteries or memory cards, and before returning to the transport container. This approach reduces inconsistency between operators and creates a repeatable sequence that can be taught, supervised, and later reconstructed if contamination concerns are raised.

Tripods and lighting devices have large surfaces and mechanical joints (locks, sections) that are difficult to decontaminate. Disposable covers for handles/locking levers are recommended, as well as separation into a dirty tripod for HOT and a clean tripod for COLD/WARM zones. All cables and adapters should be kept in sealed, clean polyethylene bags. For ALS/UV devices, controls include management of optical filters and protection from dust, and a procedure to avoid cross-touching between filters/goggles and camera operation.

From an engineering perspective, these accessories should be treated as separate contamination objects rather than as neutral extensions of the camera. Dedicated HOT-zone accessories are preferable whenever resources allow, because locks, telescopic sections, light stands, and filter holders accumulate particulate material in areas that are

difficult to inspect visually. The same logic applies to ALS goggles and optical filters.

Mobile devices are high-risk due to frequent contact, heat, and difficult-to-clean areas around ports. Therefore, replaceable protective cases, disposable transparent conductive screen films, and dedicated clean styluses for COLD/WARM use are recommended. For 3D scanners, a clear policy on surface contact, defined placement locations (clean pads), and separate transport bags/containers are required.

Equipment is carried in pre-prepared ('sealed') kits with a tamper-evident outer layer. In the HOT zone, common cases are not opened except when necessary. Instead, individual bags/containers are used for each device. This reduces the risk of contaminating the entire kit and improves traceability.

F. Operational Workflow

COLD performs battery/card checks, time synchronization, pre-set shooting profiles, attachment of protective filters and covers, marking of the kit (camera/lens ID), and recording of the initial state (CLEAN). Separate bags are prepared for used covers and waste. This preparatory step supports standardized on-scene evidence handling and preservation workflows [9].

This preparatory stage is also the correct place to define the expected photography sequence, the probable need for lens changes, and the threshold for bringing additional accessories into the scene. By making these decisions before entry, the team reduces ad hoc opening of cases in contaminated areas and limits unnecessary manipulations. Pre-entry preparation therefore has both a logistical function and a contamination-control function, because the number of later interventions strongly influences the total exposure burden of the equipment.

Entry into HOT is via a controlled access point. The camera operator should maintain minimal contact with items and surfaces. If a lens change is required, it is performed in WARM, where a clean pad and a controlled procedure are provided (change outer gloves, minimize the time the mount is exposed, immediately close and cover).

When leaving HOT, the device is placed into an outer bag/container (quarantine). In WARM, primary decontamination of the outer cover surfaces (if applicable) is performed and outer gloves are removed in a controlled manner to avoid contaminating clean zones.

In COLD, media are removed/transferred in accordance with the digital policy, secondary decontamination of the device is performed (after removing the covers), and the state is returned to DECONTAMINATED. If chemical/biological contamination is suspected, extended quarantine and consultation with competent units are provided.

G. Decontamination and Material Compatibility

Decontamination should be effective against the identified hazard while preserving the functionality of the device. A mechanical first, then chemical approach is recommended. The goal is to remove dust/particles with lint-free cloths and appropriate agents before using solutions. No liquids are allowed to enter ports and connectors. Minimal amounts of disinfectants are used for this, and controlled drying is also performed.

Cleaning actions should proceed from the least sensitive and least contaminated external surfaces toward the most sensitive interfaces, while avoiding repeated wiping that can spread residues into seams and controls. The selected cleaning agent, concentration where applicable, contact time, and any visible adverse effect should be recorded whenever the contamination event is significant.

Optical coatings and seals can be sensitive to solvents and aggressive agents. Therefore, the protocol includes using manufacturer-approved optical cleaners, avoiding acetone/strong solvents on plastics and rubber parts, and pre-installing a protective filter that is replaced/cleaned separately in the event of accidental contamination. At L3, if unknown chemicals are present, isolation and assessment prior to cleaning is preferred.

For tripods and lighting, modular approaches are used using replaceable disposable grip covers and locking levers, sealed cable bags, and separate HOT zone kits. In case of heavy contamination, disposable interfaces are preferred over aggressive chemical cleaning, which can leave residue or pose a risk to the image.

H. Digital Control of Image Integrity

To make processing defensible, the principle of minimal intervention is followed. Original files are preserved unchanged, and processing is carried out on copies. In the COLD zone, the camera/card identifier, time synchronization, file sequence, and transfer conditions are documented. The use of write-blocker devices is recommended when working with media where applicable, as well as limiting automatic editing/compression functions.

When transferring images, cryptographic hashes (e.g., SHA-256) are computed for original files and/or archives and recorded in a log. The log includes date/time, operator, source, destination, tool used, and the resulting hash values. This reduces the risk of disputes about data manipulation and complements the physical traceability of equipment.[3]

To reduce errors and contamination of the work environment, role separation is recommended: the camera operator should not simultaneously handle media processing in HOT/WARM zones. Digital processing is performed in a clean area using separate gloves or after sanitizing hands and the work surface.

Therefore, a defensible digital chain of custody should include a minimal but structured record consisting of device identifier, memory card identifier, operator, transfer workstation, transfer date and time, hash values, storage destination, and any subsequent export or processing action. When these data are linked the result is a unified traceability model in which the same device is controlled

both as a potential carrier of scene contamination and as the source of evidential image files.

I. Scenario Based Application of the Protocol

In Blood Scene/Biological Fluids (L2), the key measures include double gloves with frequent replacement of the outer layer, full camera cover, a protective filter, prohibition on placing the camera/tripod on the floor without protective pads in the HOT zone, quarantining the device when exiting, and staged decontamination. In addition, a protected area for memory card/battery changes is provided in the WARM zone.

For soot and dust, emphasis is placed on particulate control - covers with minimal openings are used, respiratory protection is worn when aerosols are possible, and mechanical cleaning is performed before using liquids. To prevent abrasion, lint-free wipes, photographic brushes, and air blowers are used, while avoiding dry rubbing on optical surfaces.

For unknown substances (unknown powders/chemical residues (L3)), the protocol prioritizes isolation and assessment, restricted access, maximum equipment barrier, sealing during transport, and postponing aggressive cleaning until the hazard has been identified. If needed, coordination with competent units for HazMat assessment is initiated.

In such situations, the protocol should explicitly allow tactical limitation of photographic actions until safe conditions are established. In other words, not every technically possible close-up should be attempted immediately if the action would require opening cases, changing optics, or bringing additional devices into a potentially hazardous zone.

III. RESULTS AND DISCUSSION

A. Practical Limitations and Implementation Considerations

Key practical limitations and trade-offs include:

- Dexterity versus barrier strength - thicker gloves improve protection but may increase the probability of equipment drops and control errors.
- Material compatibility - cleaning agents and disinfectants must be compatible with optical coatings, rubber seals, plastics, and adhesives, manufacturer guidance should be followed.
- Small team constraints - role separation (clean-touch vs dirty-touch) may be infeasible, in such cases, explicit transition rules and glove-change checkpoints are required.
- HazMat boundary - the protocol does not replace specialist hazardous-material procedures, for unknown powders/chemicals, escalation and isolation remain mandatory.
- Environmental stressors - rain, condensation, low temperatures, and dust storms may require additional protective layers and can limit decontamination options on scene.
- Consumable availability and cost - sealed kits and disposable interfaces reduce risk but require logistics and procurement planning.

The protocol is applicable as an upgrade to existing inspection SOPs, without requiring expensive equipment. The main investment is organizational, through standard kits, barrier/interface consumables, and training. The choice of materials should take into account 'evidence-friendliness', lack of release fibres, and controllable adhesives.

In the context of technically oriented protection from exposure to hazardous substances, the contribution is positioned as an 'engineering' systematization of barrier controls for device reliability and evidentiary integrity. This allows to argue the technological and managerial value of the protocol and its transferability to other field activities (emergency and rescue operations, critical infrastructure inspections).

B. Comparison to Existing Standards and Added Value

Table 3 maps the proposed protocol to existing guidance and standards and highlights the added value for photographic/electronic CSI equipment.

Table 3. Mapping to standards/guidance and added value of the proposed protocol.

Source	What it already covers	Gap for CSI equipment	Added value in this paper
Regulation (EU) 2016/425 [5]	PPE conformity and essential safety requirements for personnel	Does not specify protection/handling of reusable documentation equipment	Extends barrier logic from personnel to equipment and defines equipment states and packaging controls
ENFSI BPM-SOC [6]	Scene organization, functional areas, access and workflow principles	Limited operational detail for camera/ALS/tripod touchpoints and kit segregation	Formalizes zoning + equipment-state transitions and role separation for clean-touch imaging
FSR-GUI-0016 [2]	Contamination controls: access restriction, separation of sterile supplies from seized items	Equipment treated implicitly; lacks interface-level controls and staging rules	Introduces touchpoint mapping, glove-change triggers, sealed-kit philosophy, and staged decontamination
ISO 18385 [7]	Minimizing human DNA contamination for consumables	Not aimed at reusable devices; no operational workflow for cameras/scanners	Transfers 'forensic DNA grade' logic to reusable device interfaces and

	and packaging		cleaning/verification steps
SWGDE imagery integrity guidance [3]	Principles for maintaining integrity of imagery and workflows	Does not address physical scene contamination or equipment as trace carrier	Couples digital integrity (hash/log) with physical contamination control in one protocol

C. Sequential Summary Procedure

Before entry, the team assigns operational roles, selects the control level, prepares the camera kit in a documented CLEAN state, applies covers and protective filters, synchronizes time, and decides which accessories are genuinely necessary for the planned imaging tasks.

The sequence begins with controlled donning - the main PPE ensemble is completed in COLD, the outer glove layer is applied last, and only then is the final equipment check performed. This ensures that the first operational contact with the camera kit occurs under a known barrier condition and that subsequent glove changes can be tied to clearly defined transitions between clean-touch and dirty-touch tasks.

At the entrance to the scene, the operator confirms the transition into HOT/WARM/COLD logic, records the equipment identifier, and ensures that transport cases containing reserve items remain outside the contaminated area unless a justified operational need arises.

Inside HOT, image acquisition is performed under the principle of minimal exposed interface. Only the necessary controls are touched, the device is not placed on uncontrolled surfaces without a barrier, and glove changes are performed at predetermined trigger points rather than irregularly.

When tripod, ALS, flash, tablet, or scanner systems are used, each accessory is handled as a separate contamination object with its own covers, placement rules, and post-use packaging. This prevents the camera protocol from being undermined by inadequately controlled supporting equipment.

If operational demands change, such as the need for macro imaging, lens replacement, or movement into a more heavily contaminated sector, the control level is re-evaluated and the transition is documented before work continues.

On leaving HOT, the device enters quarantine in an outer bag or container. In WARM, the team removes or stabilizes the most contaminated outer layers, records exposure status, and prevents cross-contact between used barriers, clean consumables, and transport compartments.

In COLD, memory media are handled under the digital integrity policy, original files are transferred without alteration, hashes are generated and recorded, and the linkage between image files, device identifier, operator, and transfer event is preserved in a single log structure. To avoid contamination of memory cards and other equipment during hashing, they can be sealed in clean packaging and hashing and copying can be performed in laboratory conditions.

Secondary decontamination is then performed with agents and methods compatible with the actual material and hazard profile of the device. After inspection for residual contamination or damage, the equipment is either returned to DECONTAMINATED status or retained in extended quarantine for further assessment.

The procedure ends only when both chains are complete. The physical chain showing where the equipment moved and how it was protected, and the digital chain showing how the files were preserved, transferred, and verified. This combined closure is the core methodological contribution of the proposed protocol.

IV. CONCLUSION

An integrated protocol for the protection of photographic and electronic equipment during crime scene investigation is proposed, which treats the devices as contamination-sensitive elements rather than as neutral instruments. Through risk-based levels of control, zoning, role separation, layered barriers for equipment, staged decontamination, and traceable digital integrity control, the protocol reduces the risk of trace material transfer and equipment damage. The expected result is increased reliability in documentation and more consistent quality of work during investigations in different operational scenarios.

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