Safety Protocols for Forensic Inspections in the Time of Covid-19

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***Abstract*— The global pandemic of COVID-19 has impacted the entire world in ways that were unimaginable months ago. It has changed how professionals work and interact with one another. To ensure the safety of experts and attorneys, also forensic inspection procedures must evolve, while still providing a reliable foundation for an expert testimony, relevant to the task at hand. Traditional field inspections require attendees to be physically present and generally in close proximity. Inspecting artifacts may also require that individual components be serially examined by multiple experts, which increases the risk of transmitting the disease. The authors propose a new approach to forensic inspections aimed at protecting consultants from the biological risk due to COVID-19. This approach takes into account the anti-contagion safety protocols established in affected countries around the world.**

***Keywords:* Covid-19, forensics, inspections**

I. Introduction

The recent unpredictable global outbreak of COVID-19 has greatly impacted all working activities, both indoor and outdoor. To limit the spread of the virus, national and local governments worldwide have issued specific emergency laws, decrees, and regulations, such as "Stay at Home" and "Shelter in Place" orders. The purpose of the orders is to increase the social distancing requirement and to still allow the operations of business, as long as the social distancing rules are maintained. Restrictive regulations permit only essential working activities, and only in the presence of specified anti-contagion safety protocols, to function, so as to ensure adequate levels of protection for workers and citizens.

As an example, in Italy, one of the most affected countries by COVID-19 in the world, the national government has established clear rules for all working activities during the lockdown via the Prime Minister Decree issued on March 23, 2020 [1].

The decree also included professional activities of Engineers and Architects. In particular, Professional Engineers (P.E.) activities have not been suspended, but have been allowed to continue, as long as conducted in accordance with the safety recommendations given by DPCM 11/3/2020 art. 1.7 [2], and with the "Shared protocol for the regulation of measures to combat and contain the spread of Covid-19 virus in the workplace" of 14 March 2020, applicable to construction sites, workplaces and professional firms [3].

COVID-19 is a biological hazard (i.e., Biohazard Level 4) that may cause severe to fatal disease in humans, and for which vaccines or other treatments are not yet available. Accordingly, the safety measures against the infection can be summarized as follows:

- Adoption of anti-contagion safety protocols;
- maintain social distance;
- recurrent hand washing with water and soap;
- restrictions to the movement of persons;
- smart working and remote communication with clients.

Based on the above, to ensure the safety of experts and attorneys, also forensic inspection procedures must evolve, while still providing a reliable foundation for expert testimony, relevant to the task at hand.

Traditional field inspections require attendees to be physically present and generally in close proximity. Inspecting artefacts may also require that individual components be serially examined by multiple experts, which increases the risk of transmitting the disease.

The above issues may be resolved with "remote access" inspections, which may become the new normal in the forensics field. Remote access is based on modern technologies that can allow the fulfillment of the scope of the field investigation and may allow the recording and transmission in real-time of all its phases. This would also allow the recording and memorialization of all inspection activities, which are traditionally not permitted, unless with the explicit consent of all parties involved.

Remote access inspections are safe, more efficient thanks to the absence of travel time, and with the remarkable advantage of providing unique views of the area, process or artefact, by means of cameras and the devices used to hold them. Inaccessible areas to be inspected may be viewed using drones or robots. Recordings may be made available also asynchronously, on-demand.

Based on the above, the authors discuss a new approach to forensic inspections to reduce biological risk due to COVID-19.

II. The Importance of Forensic Inspections

To establish the cause(s) of an accident resulting in a legal claim (or to investigate a crime), the place where the accident occurred and the equipment involved (i.e., physical evidence) need to be examined by all parties (i.e., attorneys, experts, law enforcement, etc.). As correctly reminded in [4]: *"The quicker the investigator(s) come on scene, the more likely they are to collect data that accurately reflects the true facts of the incident".* The preservation of the accident scene and of the artifacts (or buildings) until the inspection is a crucial aspect of every legal claim, as it provides the elements for the reconstruction of the accidents, and the identification of the root cause(s) [5]-[10].

The inspection must occur in the shortest time possible to prevent loss of evidence due to external factors, such as weather (e.g., low or high temperatures, rain, etc.), natural ageing of materials, movement of the equipment, unauthorized changes in the wiring, cleaning and sanitization of the areas where the accidents occurred, spoliation of evidence [11], etc. Delay in forensic inspections may make impossible to establish the root cause of accidents. Reference [12] describes the case of a fire in a shopping center, with a long delayed multi-party inspection. When the inspection was scheduled, the damaged equipment has been transported from the fire site to an outdoor storage area, without previous identification of parts or a documented chain of custody.

III. Measures to mitigate virus transmission during in-person inspections

In-person forensic inspections may be permitted in some countries. However, measures to mitigate the virus transmission should be followed.

A. *Prior to the inspection*

Attendees shall be limited to the minimum personnel required to accomplish the inspection. A secure video feed may be made available upon request to permit additional parties to observe, as necessary.

If the inspections are to be performed in a public or crowded place (e.g., street, square, open to the public building, etc.) and it is not possible to prohibit at all the presence of public, the access of the public must be reduced as much as possible. Mobile barriers may be put in place to ensure social distance.

On the day preceding the scheduled inspection, the project manager shall coordinate with all potential attendees. If any of the following questions are answered positively on that day, or on the day of the inspection, personnel substitutions shall be made.

- Is the attendee experiencing symptoms that could be related to COVID-19?
- Has someone in the attendee's household tested positive for COVID-19?
- Is anyone in the attendee's household sick or experiencing symptoms that could be related to COVID-19?

Before entering the inspection site, the body temperature of attendees shall be checked. If the attendee's temperature is higher than 37.5 °C, access to the inspection site shall be denied.

Individual attendees (unless residing in the same household) shall be expected to travel to the inspection site via separate vehicles.

B. *During the Inspection*

At all times, a minimum of 6-ft. (2 m) distance shall be maintained between all attendees when in the facility or site and during the inspection activities. Should the inspection be performed in confined areas, one attendee at the time shall be allowed in that area.

In addition to any personal protective equipment required due to the nature of the inspection (e.g. hard hats, gloves, etc.), each attendee shall continuously wear a mask that covers their nose and mouth while in the facility or site. This may be a cloth mask or bandana.

Any attendees needing to physically contact artifacts or other materials in the facility or site shall be wearing gloves. Attendees shall periodically make use of hand-washing facilities or alcohol-based hand sanitizer, including after removing gloves, and before and after contact with common touch surfaces. Attendees shall also make use of disinfecting wipes, and any common touch surfaces shall be wiped down prior to and after use.

Attendees not adhering to these guidelines shall be precluded from the inspection and may be asked to leave the premises.

C. *Possible diffusion of COVID-19 via aerosol*

COVID-19 is believed to be transmitted from person to person by [13]:

- close contact with an infected person;
- inhalation of respiratory droplets produced by an infected person;
- contact with surfaces contaminated by the virus

According to the World Health Organization, "*the COVID-19 virus spreads primarily through droplets (i.e., aerosols) of saliva or discharge from the nose when an infected person coughs or sneezes […].*" Aerosols, like gasses, may travel through the air for longer distances, and transmit to persons and settle on surfaces. Because such small particles remain airborne for some time, the risk of contracting the disease during inspections indoor or in confined areas is greater.

Reference [14] indicates that ventilation represents a primary control strategy against infectious disease by the dilution of room air around a source, which may remove infectious agents. The party hosting the inspection, therefore, should guarantee that HVAC systems move the air at a ventilation rate significantly higher than that typical of natural ventilation (e.g., user-operable windows).

IV. Remote Access to Inspections

With the tools and technologies that are available today, remote inspections are an excellent alternative, providing first-hand views that enable distant users to virtually participate and oversee the inspection. The ubiquity of the internet makes it easy for participants to log into a screen-sharing tools such as Microsoft Teams, WebEx, or Zoom. Any of these tools provide a platform useful for viewing the feed from an inspection that is distant from the participant and allows for two-way communication with other participants and the engineers and technologists at the inspection site.

For complex lab inspections, multiple feeds should be supported. In this setting, it is important to include a *producer*. The producer is typically a technologist who has a computer capable of consuming many feeds available within the lab setting. A usual setup will include stationary webcams, mobile cameras including devices like GoPro cameras and smartphone cameras, and feeds from instruments located within the lab such as optical microscopes, electron microscopes and other data collection devices such as lab-based laser scanners. Each of these feeds is collected live simultaneously in the producer's computer. The producer then controls which feed or combination of feeds are sent to the webshare. The participants view the stream that is curated by the producer and because they have two-way communication may make requests of the producer and the engineers in the lab.

An important question to consider when conducting a remote inspection is whether to record the video feed and/or the audio feed. It is technically possible to record all of the video feeds supplied to the producer and the curated feed that is shared with the remote participants. Some of the video feeds may include audio if the camera or capture device is equipped with a microphone. The curated stream recording captures the video and the audio. The question remains one of the protocol. Do the participants in the inspection, both local to the inspection and remote wish to have the event recorded? Protocols developed in advance need to address this issue and it does not need to be an all or none solution. If a particular sound needs to be recorded as part of the inspection, that can be done an other audio during the inspection does not have to be recorded. These are important decisions that should not be left to the day of the event.

There are other protocol considerations that apply when remote participants are allowed into inspections. Beyond simply recording the audio, participants at the inspections may need to have private conversations during the course of the inspections. Spaces away from the inspection may need to be provided that allow for private phone calls or other means of private communication. Security must also be ensured and agreed upon. Different web sharing platforms have differing degrees of security and this should be considered carefully. Beyond someone gaining access to the videoconferencing, how do you handle participants that may enter the office of someone legitimately remoted into an inspection. They could attend essentially undetected. These kinds of issues should be considered in protocols.

Finally, the companion to the live videoconference is the web portal and the value of this feature should not be underestimated. The portal allows for near real-time sharing of images captured during the inspection. This is important because the quality of a video feed may not be good enough to support a detailed examination of an object. It allows a remote user to follow the events at the inspection, frequently with better views that one gets in person. However, the resolution of an internet stream is limited. The portal can serve as a repository of high-resolution photographs taken at the inspection and uploaded via wired and wireless camera tethers. Images captured with a microscope or SEM can also be shared within seconds to minutes of capture via the portal. It is clear that combining portal access with the live experience is needed to provide a quality remote inspection.

V. Remote Access to Post-Inspection Data Analysis

Once the onsite work is complete, post-inspection data analysis sessions can also be conducted remotely, enabling efficient collaboration while minimizing the need for travel.

Some data captured at an inspection require processing before it can be reviewed and, therefore, is not immediately available for analysis at the time of the inspection. For example, when capturing a scene or complex object like a transformer of a substation with a laser scanner, multiple scans must be aligned to construct a meaningful 3D representation of the scene. Post-analysis of these data types is extremely valuable and often informs the next steps in the investigative process. This makes it important for all stakeholders to be involved in this process. Fortunately, data analysis sessions are also accessible by remote participants.

The easiest and most popular method of engaging remote participants in post-inspection data analysis is screen sharing a technologist's computer via tools like Microsoft Teams, Zoom, or WebEx. This allows a technologist to virtually lead participants on a virtual walk-through of 3D data captured at a scene, review floor plans that are generated from the 3D data, and share photographs taken at the time of the scan. All these steps are helpful in generating an intuitive familiarity with a scene for all those engaged in the process. In many cases, perhaps only the technologist and consultant were physically present when the scene was captured. By sharing the 3D context for the scene, all stakeholders can better grasp the concepts that emerge as the consultant conducting the investigation leads them through the data in context.

Another more immersive way to engage with 3D data is virtual reality [15]. Head-mounted displays (HMDs) pull viewers into a virtual space allowing them to perceive the scene with all its depth because it is displayed stereo optically. Because HMD's also provide the computer with positional information, users wearing head-mounted displays can move within a scene and their head movements and even positional changes via walking in some systems are detected. This allows the user to interact very naturally with a virtual 3D scene in a 1:1 or some other predefined scale. This sounds like a private experience, but there are two ways to share it. First, a screen rendered version of the VR experience can be shared via the web-sharing tools we are all now accustomed to. This allows one person using an HMD to provide a guided experience much like the 3D guided experience described above from the remote participants' perspective. The remote user will view a screen and follow along coupled to the view of the guide who is in VR (Figure 1).

Fig. 1. Screen sharing VR.

The second more engaging method of sharing 3D space was pioneered in the gaming industry. This technique engages multiple users in the same 3D environment. Akin to the web-sharing applications, these tools allow users to interact, but unlike web-sharing applications, multi-user VR applications engage users in the same virtual space (Figure 2). It is like being in a real space together, in that each user has a personification, an avatar, and users can see each other's avatars and have two-way audible communication. In these virtual environments, users of HMDs and conventional computer screens can interact with one another inspecting a digital version of a railcar for example. While this method generally requires more powerful hardware than a web-sharing application, newer techniques are making this engaging experience possible on more modest equipment including smartphones.

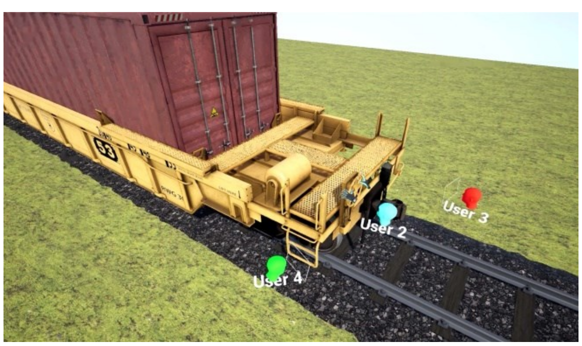

Fig. 2. Multi-User VR.

Other specialized instruments may also provide data that is beneficial to access after processing. Industrial Computed Tomography scanners (CT scanners) provide a wealth of information on the interior features of components non-destructively. CT scanning before disassembly of components is becoming a common practice in inspections where a non-destructive record of the component is important. Like 3D laser scanners, most data from CT scanners requires a period of processing that makes real-time access at the time of scanning not particularly informative. It may be valuable to view part loading into the scanner to review the physical setup for the scan, but the data analysis session will come later, after processing. This is accomplished through a technologist screen-sharing his or her view of volumetric analysis tools. Remote participants can direct the tech to show specific views or digital sections through the component.

Post-inspection sessions are easier to manage than multiparty inspections because they typically involve only one party. They are often informational and exploratory in nature, providing a number of the remotely engaged participants a first look at data gathered from a scene. In many post-inspection analysis sessions, ideas emerge for next steps to visualize a process or to understand better what happened that led to the state of the objects in the scene at issue. For this reason, it is good practice to have as many stakeholders as possible involved. Often scientific insights should be viewed through a number of perspectives as next steps are charted for the matter at hand and these perspectives can be efficiently captured and debated in a post-inspection analysis session.

VI. The Role of Forensic Institutions

Reference [16] highlights the important role of forensic engineering associations and institutions around the world in defining the level of competence of the forensic engineer, improving the practice and elevating forensic engineering standards. One of the goals of these associations (a not-exhaustive list is reported in Table I) is to support the continuing education of P.E. in the field of forensic engineering, sharing knowledge and experiences. During the COVID-19 global emergency, these associations may provide advice in the matter of safety by sharing recommendations and safety protocols for in-person inspections.

TABLE I. International Forensic Science Associations

America	AAFS: American Academy of Forensic Sciences (USA)
	AICEF: Academia Iberoamericana de Central & South Criminalistica y Estudios Forenses (South America)
	BFDE: Board of Forensic Document Examiners (USA)
	IBFES: International Board of Forensic Engineering Sciences (USA)
	NAFE: American National Academy of Forensic Engineer (USA)
	OSAC: Organization for Scientific Area Committees for Forensic Science (USA)
Asia	AFSN: Asian Forensic Sciences Network (Asia)
	JAFAST: Japanese Association of Forensic Science And Technology (Japan)
Africa	SARFS: Southern Africa Regional Forensic Science Network (South Africa)
Europe	AIF: Italian Association of Forensic Engineers (Italy)
	CSoFS: Chartered Society of Forensic Sciences (UK)
	ENFSI: European Network of Forensic Science Institutes (Europe)
Oceania	ANZFSS: Australian and New Zealand Forensic Science Society (Australia and New Zealand)
	SMANZFL: Senior Managers of Australian and New Zealand Forensic Laboratories (Australia and New Zealand)
Global	IICFIP: International Institute of Certified Forensic Investigation

	Professionals

VII. Conclusions

This paper is based on [17].

Inspections of physical evidence are crucial to reconstruct accidents and establish their cause(s). Traditionally, consultants do perform inspections in close interaction with other attendees, which may favor the transmission of the Covid-19 virus.

In this paper, the authors have substantiated that the "new normal" for forensic inspections must be based on either the strict application of specific measures for mitigating the risk of spreading diseases, or on the recourse to remote access and remote access to post-inspection data.

Remote access to the different phases of an inspection allow firsthand views of artifacts or scenes, and a two-way communication among parties; they minimize risk, optimize time and reduce the costs of the attendance of the participants.

With the tools and technologies that are available today, remote access to an inspection may even allow a more effective approach than in-person inspections. After processing the data captured in the field or laboratory, a meaningful 3D representation of a scene or an object can be produced. The 3D model may reveal details that otherwise might go unnoticed, allowing to better grasp the causes of the accident.

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