GSTF Journal of Law and Social Sciences (JLSS)
DOI: 10.5176/2251-2853_5.1.194
Print ISSN: 2251-2853, E-periodical: 2251-2861 ; Volume 5, Issue 1; 2016 pp 46 - 50

Preservation of dangerous forensic samples of evidence with the use of mobile robotic system

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Abstract – The richest source of information about crime and criminals is the place of the incident. From the point of view of forensics the examination of the crime scene is the primary activity of inquiry and it is the core action at the scene. However, there are scenes in which conditions threaten the health and lives of investigators, e.g. an illegal laboratory of controlled substances. However, there is a need to disclose, transport and store the obtained evidence, which is a source of danger, for the purposes of criminal proceedings. Police Academy in Szczytno (Poland) conducts a research project, which aims at the development of innovative solutions and technology that will enable proper and effective protection, transport, storage and disposal of such hazardous material evidence. A solution that would eliminate these risks is a robotic system for taking samples (e.g. samples of reaction mixtures). With a view to safety of SOCOs the proposed solution is of major importance.

Keywords: illegal laboratory; crime scene; preservation of samples; evidence material; modern technologies; robotic system

I. INTRODUCTION

Without the participation of criminology many crimes remain unsolved – in other words, the detection of crime generally requires the involvement of forensic science. The richest source of information about crime and criminals is the place of the incident. It is said that a crime scene is a silent witness [1]. The basic principle of study of a crime scene was established at the beginning of the twentieth century by the eminent crime expert E. Locard and it reads as follows: *every contact leaves a trace*. This can be interpreted as follows: a criminal leaves something at a crime scene and takes something away from there. Therefore, it is necessary to isolate the crime scene to secure the evidence [2]. The concept of the trace is one of the key issues in criminology and is closely linked to the very important issue of identification. Effective use of forensic evidence is equivalent to the maximum extraction of the content contained within the information and then using it in all possible ways [3]. Unfortunately, in practice it is not always easy. Securing a trace can be difficult and sometimes even dangerous – more on this later.

From the point of view of forensic science, the examination of a crime scene is the primary activity of inquiry and it is the core action at the scene. In criminal proceedings these are, in many cases, the foundation for the entire case [4]. The role of this process and forensic activities in the investigation of crimes is crucial. The subject of the examination is often a scene in which disclosure and securing traces can be – because of conditions there – particularly dangerous to perform, posing a real threat to SOCOs (Scenes of Crime Officers), i.e. persons whose task during the examination is to reveal and secure evidence and other objects. The first problem that must be addressed in such a situation by SOCOs is their own safety. An example of (quite extreme) such a crime scene is an illegal lab of controlled substances, also known as illegal drug lab. It is a place where there is equipment – tools and chemicals – needed to carry out chemical synthesis in order to obtain synthetic psychoactive substances (in other words, synthetic drugs). Referring to such an example here is not accidental. Under Polish law, an illegal drug lab is a crime scene, in which synthetic controlled substances are illegally produced. In the years 2000-2013 – according to data from Polish Bureau of Investigation – in Poland there were liquidated 192 illegal laboratories producing synthetic drugs (mainly amphetamines). Annually about 15 such places are liquidated in Poland. This country is not seen merely as a transit country when it comes to drug

trafficking, yet it is treated as a "serious" producer of amphetamines and "serious" client. Poland is indicated in 30% cases of seizures of amphetamine sulphate [5]. Generally, the scale of synthetic drug production in Europe is large, and amphetamine is considered as a "typical European" synthetic drug [6].

The problem in Poland are not only illegal drug laboratories and the issue of their liquidation, but also the evidence disclosed and protected during the examination of the place. These include various chemical reagents, reaction mixtures, waste from production and laboratory equipment. This is a type of evidence that causes, due to its specificity, a lot of problems, but on the other hand it is essential to prove that at a given location the synthesis of drugs took place. During the examination one of the most important tasks involves collecting samples for testing identification of these reaction mixtures and waste. This must be done in such a way as not to endanger SOCOs by, inter alia, inhaling the vapours of organic substances. Given risks which are present in an illegal drug laboratory, one of the factors that could be eliminated can be the use of robotic systems for taking samples. In other words, we should seek the solution in modern technology, which is very important from the point of view of e.g. work safety.

Modern times place new demands on the prevention and combating of crime. New solutions and tools to support this process are constantly developed and implemented to the practice of forensics. It is the natural state of affairs, because we know that forensics is an interdisciplinary science, which from the very beginning has been using for its own purposes concrete achievements from various fields of science, technology and even art. The above-mentioned E. Locard argued that during study crime techniques the forensics combines various sciences. However, even he could not have predicted how far technology would develop to help forensics. The XXI century has without a doubt proved that scientific and technological achievements have enriched the catalogue of means and equipment of forensic techniques that can be used, among others, during examination at the scene. Development of new technologies conducive to criminology and a systematic development in research is observed, which result in innovative solutions and tools to simplify and support the work of SOCOs and other experts. One of the modern solutions in criminology are, inter alia, mobile robotic systems. However, it cannot be expected that during the examination of the scene a robot will replace SOCOs. The assumption is that, if possible, the robot will replace humans in conditions where harmful factors make it impossible for them to work safely.

II. THEORETICAL RATIONALE. THE CONCEPT OF THE RESEARCH PROJECT

In practice, in the activities of law enforcement agencies and the judiciary it is necessary to protect, transport and store evidence for future criminal proceedings that due to its chemical, biological or other properties is a source of danger. Such evidence is termed: difficult trial evidence. Illegal drug laboratories are places where explosives or pyrotechnic materials can be found or products filled with such compounds, as well as it is a place where an explosion of explosive materials or devices could have occurred (regardless of its type) are examples of scenes where conditions threaten the health and life. In order to effectively fight against illegal drug labs we need to define them, determine conditions of their operation and, what is extremely important, to prove that controlled substances (drugs) are produced there. Authorities can do this on the basis of evidence disclosed and secured during the examination activities of an illegal lab. It should be noted that for the Polish law enforcement authorities the said evidence (as such) is often a bigger problem than just the issue of liquidation of the place. Security, transport and storage of evidence disclosed during operations carried out during the examination of an illegal drug manufacture of controlled substances is currently one of the most difficult and unsolved problems [7].

Lack of uniform standards and organizational, legal and technical procedures in dealing with problem trial evidence has inspired us to develop the concept of a research and development project entitled *Infrastructure, equipment and procedures for technical and legal aspects of security and storage of the so-called "difficult" trial evidence*, which was developed in response to a call for proposals announced by the National Centre for Research and Development for the execution of projects in the field of research and development for defence and national security. Police Academy in Szczytno (Poland) has been granted funds for the implementation of this project. It is worth noting that the National Centre for Research and Development (Warsaw, Poland) is an executive agency of the Minister of Science and Higher Education. It is a unit carrying out tasks of science policy, technology and innovation. The Centre provides a platform for effective dialogue between science and business environment. The Centre is funded by the State Treasury and the European Union funds.

Implementation of this project began in 2014. The partners of the Police Academy in Szczytno (Poland) in the project are the following institutions: Military Institute of Chemistry and Radiometry, University of Bialystok and Industrial Research Institute for Automation and Measurements. The main objective of the project is to develop or adapt infrastructure, equipment and technical and legal procedures related to securing, storage and disposal of the so-called difficult trial evidence. The items that are significant to the safety of people are considered as priorities during the development of the proposed technology. Achieving the objectives of the project

will increase the efficiency of the services responsible for national security.

A. Characteristics of "difficult" trial evidence

Forensic traces and other objects secured during examination constitute material evidence. It is worth noting that if the evidence is not collected and secured *lege artis*, then even the most perfect test method used in the laboratory by an expert will not give any results or the outcome of the research will be false. However, there are crime scenes within which securing the evidence is associated with the risk for a SOCO. It has already been mentioned that one example of such a place is an illegal drug lab. Sources of threats at such a place are mainly ongoing chemical processes, chemical fumes, makeshift solutions e.g. the electrical system. In the case of an illegal drug lab we have to deal with evidence, which constitute of:

- psychotropic substances, intoxicants and precursors;
- substances harmful to human health and life, e.g. acids, hydroxides, organic solvents;
- production waste;
- flammable substances;
- significant amounts of equipment and chemical apparatus.

Explosive substances and materials are also frequently found and secured. All of these above substances are termed: difficult trial evidence. That evidence needs to be secured for future criminal proceedings and its role is crucial to prove that at a given place the synthesis of controlled substances occurred. As part of the forensic expert opinions, qualified chemists will have to give answers to the process authorities for the following questions (among others):

- did a process of producing or processing a chemical substance actually take place at the scene?;
- whether or not the produced chemical compound(s) is under the law regarded as psychotropic substance, narcotic or a precursor used in the production of these substances and products?;
- what is the quantity, purity and estimated black market value of secured drugs and precursors?

Often experts in their opinions must also answer the additional questions. The information necessary to answer the above questions is provided by the evidence secured in the laboratory [7,8]. Equally important are issues related to securing, transporting and storing the evidence, mainly because of the threat to life and health that they may cause.

B. Modern technologies in forensic science

Over the centuries, every human invention and any new technology after their implementation have been very quickly acquired by such customers who have used them contrary to the original purpose, including for criminal purposes. Today modern technologies and innovative solutions are necessary to fight against committed crimes. In the fight against crime we use tools developed in many different fields of science and technology, and forensics is characterized by the fact that for years it has continuously adapted these achievements to its needs. And so, during the examination of a crime scene an entire spectrum of means and equipment is used for both the disclosure and protection of forensic evidence, as well as for preparing technical documentation of this activity. It is without a doubt that the twenty-first century with its scientific and technological achievements have increased the catalogue of means and equipment of forensic science techniques, which a SOCO has at his/her disposal during the examination of a scene and during testing in the lab in the process of forensic identification. Development of new technologies constantly accompanies and consolidates criminology. In the environment of forensic experts there is an ongoing discussion on the role that a robot could play during operations at the crime scene. Properly equipped robotic systems are characterized by the ability to detect threats, which humans cannot detect with their own senses, and constant capability of working in conditions adverse to human health. Therefore, the question arises: is it possible to develop a solution that would replace a SOCO in such a scene in which there are factors that threaten his/her security?

III. PROJECT – STAGES OF IMPLEMENTATION

As part of the research phase of the project comprehensive data on substances classified as difficult trial evidence and their properties was collected. On this basis, a computerized database containing complete information about the evidence of this type was created. We gathered information on practices in securing and transporting the above-mentioned substances and conducted detailed analysis in the light of current technical capabilities in this area. We analysed information on technical instrumentation used by different services for securing the operation of hazardous substances and a reference was made to the current legislation in this area.

During the next stage of the project a preliminary model of protection technology of difficult trial evidence at the scene and during transport was created and a model of conduct in their storage and liquidation was proposed.

Then, in one of the tasks of the project a mobile system for sampling liquid and powdery substances known as difficult trial evidence was designed, developed and tested in operational conditions. The design of the mobile system is based on the robot *PIAP-Gryf*® developed by Industrial Research Institute for Automation and Measurements. Works on this solution began by defining the conditions to be met by device of automatic sampling of evidence during the examination of the scene. It takes into account the fact that for the purposes of forensic identification only test samples are collected (two sets). In the case of such evidence, as the reaction mixtures, production waste or chemicals, test samples

are collected. They are secured from the same material evidence in the amount ranging from 2 to 5ml (max) and from 0.5g to approx. 2g (max). The method of sampling for laboratory tests is very important because the samples must fully reflect the composition and proportions of the entire piece of evidence. In other words, the samples must be representative. In the case of multiphase mixtures we need to secure each of the phases for further testing. We can often come across evidence, which is a mixture of solid and liquid substances. Therefore, samples from each of the phases need to be secured and in the report we need to state what proportions were between them. It happens that the sample must be secured with a heterogeneous mixture of solids. In such a case one way is to homogenise the mixture before sampling. Samples of evidence must be taken with the use of clean, disposable devices and put to clean new tubes or other containers (chemically inert with respect to the secured material). It must be remembered that among secured mixtures/substances there are corrosive, flammable or carcinogenic substances [7].

The designing phase of mobile robotic system for sampling liquids began with the production of model frames that are to take into account the expected components, including:

- bellows bottle,
- peristaltic pump,
- control electronics and the concept of sampling.

Tests of the model of technology were carried out in conditions similar to the real ones. They showed the correctness of the concept in the context of observing the working field of the device by robot cameras. Then, a project of the device in the form of a 3D computer model was developed. The next step consisted of further manipulation testing of the device model, prepared in the *rapid-prototyping* technology. Simultaneously, we conducted works to develop the concept of sampling tools for powders (solids). A series of tests using various types of solids was carried out. The tests had been designed to verify the functionality of handling the instrument during tests of sampling using a mobile robot and to verify the operation of the device under laboratory conditions as close as possible to real environment. Using images from the cameras, the robot operator was able to immerse tools in powders and with simple movements of the manipulator was able to take samples using the hopper tool. The tool also tested the ability of the device to extract powders from sealed packages that were pierced with the tip of the blade of the tool. We have successfully sampled three types of powders out of two types of packaging (paper and plastic) and scattered solids (at different angles of approach).

Summing up, the basis of the mobile robotic system is an unmanned platform through which the robot during the examination gets to the place where a sample needs to be collected. The mobile platform is equipped with suitable instrumentation for taking liquid and powdery samples. Operation of the system is done by the operator through the console.

IV. Conclusions

The quality of the activities performed during the examination of a place, in particular the quantity, quality and the relevance of the secured evidence, has substantial influence on the success of further actions, and often on the outcome of the entire criminal case. Technological progress that is occurring in the practice of forensic science aims at facilitating actions of on-site examinations and in forensic laboratories. The innovative solution proposed in the implemented project is mainly characterized by the fact that it will be a complete solution for the needs to secure, store (for legal purposes) and dispose of evidence belonging to the group of the so-called difficult trial evidence. The mobile robotic system for sampling evidence, which is one of the elements being developed, is expected to meet the following requirements:

- items used for sampling are to be resistant to various chemicals, including solvents and corrosives,
- ability to take small samples,
- sampling tips can be easily replaced (a new tip is used for each sample),
- the shape and dimensions of the tips are to enable sampling of liquids and powders to standard laboratory vessels (i.e. vials used in drug research labs),
- possibility of cross-sampling of liquid multilayer substances.

At the current stage of the project we are testing the robotic system in real conditions. The aim of the test is to check the current set of replacement parts and supplies, among others, for: resistance to aggressive liquids, the right amount of taken samples, improvements in the design of tools which enable the easiest and most reliable sampling of substances.

The current state of robotic technology allows the systems to take over some of the tasks conducted by SOCOs, which do not diminish their role on the scene – on the contrary, a SOCO must monitor the implementation of these activities and ensure the correct course of taking samples. The proposed mobile robotic system for sampling of evidence minimizes the exposure of health and life of SOCOs and further streamline the process of securing evidence. As a result of all these activities it will contribute to improving the efficiency of activities performed during on-the-spot examinations.

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