SHUTTLE general introduction

SHUTTLE, acronym for 'Scientific High-throughput and Unified Toolkit for Trace analysis by forensic Laboratories in Europe', is a project financed by the European Commission[1]. The development of the SHUTTLE toolkit will be realised through a pre-commercial procurement (PCP) action[2], which is coordinated and jointly carried out between forensic institutes across Europe. More precisely, the forensic institutes will organise and manage a call for tenders and select the companies that will perform the necessary R&D activities to develop the SHUTTLE toolkit. Thanks to the EC funding (7.4M€ for the subcontracted activities), the SHUTTLE project will contribute to strengthening the forensic collaboration across countries and institutions in Europe and possibly beyond. It also will catalyse innovation by allowing public authorities to invest cost effectively in innovation by sharing costs and lessons learnt.

This document provides a general introduction to SHUTTLE and will also explain how you can be involved in SHUTTLE.

1. Vision

SHUTTLE will automate a significant part of forensic microtrace evidence examinations. The core of the SHUTTLE toolkit will consist of an automated microscope that will acquire high quality images of recovered microtraces. The acquired images will be processed automatically and an overview of available microtraces will be reported. In first instance, we will focus on blood, skin cells, gunshot residues (especially NC), hairs, fibres, and saliva. Algorithms to classify additional microtraces, or to classify microtraces more accurately can be developed by users and added as plug-ins to extend the range of microtraces that can be classified. The data will be stored in a computer database, thereby facilitating future data analysis, such as provenancing of microtraces and forensic comparisons.

SHUTTLE aims to solve two major issues in forensic microtrace evidence investigation.

First, Current analyses are subjective and require a high level of expertise and training of examiners. SHUTTLE will render analyses more objective and scientific. Second, microtrace evidence analyses are time consuming and hence expensive. This limits the number of cases in which analyses can be carried out.

---

1 H2020-SEC-2016-2017, Grant nr 786913.

2 Public procurement is the process whereby public authorities purchase equipment and services from the commercial sector. Pre-commercial procurement is a special form of public procurement which is adapted to research and innovation: public authorities in a step-by-step process select organisations which offer to carry out research and innovation activities. After a first early prototyping stage, a reduced group of finalists is retained to deliver the final prototypes. Based on the outcome, then a commercial procurement phase starts. For more information, see: https://ec.europa.eu/digital-single-market/en/pre-commercial-procurement

This project has received funding from the European Union's Horizon 2020 Programme under Grant Agreement (GA) N° # 786913

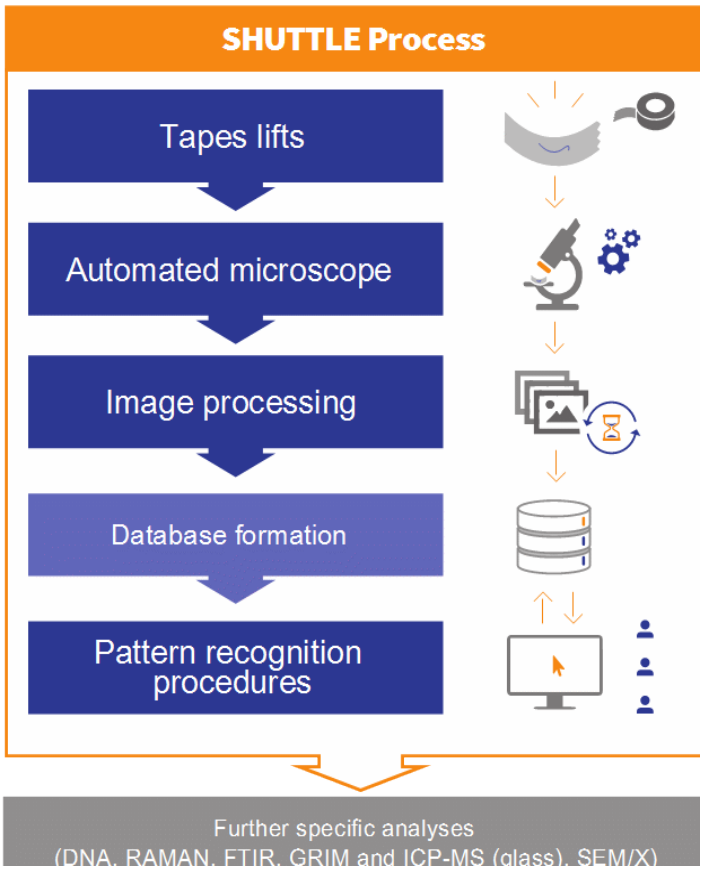
Introduction of the SHUTTLE toolkit will have several advantages for forensic laboratories and their customers. The automation will allow a more efficient work flow, while the obtained results are more objective. The objective nature of the analyses and the available database will enable national or even international exchange of data.

Wide implementation of the SHUTTLE toolkit will homogenise the procedures for microtrace evidence examination in laboratories throughout Europe and hence facilitate better international collaboration and exchange of data. Laboratories may use data in a shared database for their database searches. In a similar way, data acquired by several laboratories can be used to calculate background populations and the calculation of the evidential value of the results. They may ask for help from international colleagues by just indicating a reference to the key under which data is stored in the joint database.

The standardisation of working procedures will form an excellent educational tool, as police officers and forensic can improve their knowledge by studying samples in the database. The SHUTTLE toolkit will also form a major incentive for Research and Development studies, e.g by enabling discrimination and background studies.

2. Concept

The SHUTTLE toolkit will contain 4 tools. Each of these tools, as well as their fluent interaction, is required for optimal operation.



- Microscopic grade tape. Tapes have been used to recover microtraces for several decades. Their popularity is based on easy handling, low cost, and efficiency for many types of microtraces. A current disadvantage of tapes is that microscopic images acquired through tapes do not yield optimal image quality. Therefore, relevant microtraces are often transferred into glass slides to improve image quality. The tender will include the supply or development of a tape that allows imaging quality comparable to glass slides and facilitate analysis on surfaces much larger than can be achieved by standard glass slides.
- An automated microscope that will form the *eyes* of the SHUTTLE toolkit. It will acquire high quality images of microtraces that have been recovered using the developed tapes. The microscope will use a number of illumination modes for optimal discrimination and classification of microtraces. The microscope allows spectrometric colour analysis The classification will be aided by

advanced polarisation analysis. The required spatial resolution is moderate, but the total field of view is large, while acquisition time must be acceptable. The SHUTTLE microscope will be operated using clear and intuive software. The software allows the definition of a standard analysis procedure. In addition, there is a feature for advanced users that allows data acquisition using non-standard parameters.

- Algorithms for image processing that will form the *brain* of the SHUTTLE toolkit. The algorithms will process the images acquired by the microscope and classify the different types of microtraces present in the tape. The results of the algorithms is a table that contains a number of parameter vectors for every microtrace, such as the coordinates on the tape, the colour, polarisation characteristics, morphology, and class (e.g. 'blood', 'fibre', 'glass', etc.). These algorithms can be executed via a GUI (graphical user interface). Via this GUI, users can execute the algorithms developed within the SHUTTLE project. In addition, the can develop and share additional algorithms and plug them into the the GUI. Such additional algorithms may serve to classify additional microtraces, or to make a better subclassification. As an example, the SHUTTLE toolkit might classify a microtrace as a 'hair', while additional algorithms can discriminate and classify 'scalp hairs, 'pubic hairs', 'body hair', or even discriminate hairs from different animals.
- A database and search algorithms, that will form the *memory* of the SHUTTLE toolkit. This database will contain the data (raw, processed or both) acquired by the microscope and processed by the image processing algorithms. The database structure is made in such a way that the data acquired by the SHUTTLE toolkit can be related to data acquired by other techniques. To achieve this, it is possible to add into the database parts that contain data from e.g. FTIR, MSP, dye analysis, etc. The database contains a robust back-end and a user-friendly front-end. The front-end should have the same look and feel as (or even be integrated with) those for instrument and the image processing routines. The database will focus on experimental data and will (as is currently foreseen) not contain case information (such as case identifiers, names of suspects and victims) to prevent security and privacy issues. The search algorithms should allow searches for similar samples in the database. The search algorithms yield numbers or probabilities that can be used to calculate the evidential value of a result, e.g. using Bayesian statistics.

We aim to make the SHUTTLE toolkit powerful and versatile to such an extent, that it will become an international standard in forensic microtrace evidence examination. Therefore, the specifications will not only cover the technical aspects. Additional specifications will be set on privacy issues, training, user-friendliness, long-term sustainability, and integration with other techniques.

3. Scenarios

This section provides a number of scenarios on the use of the SHUTTLE toolkit. These scenarios explain how the SHUTTLE consortium intends to implement the toolkit into the forensic practise. Note that these examples do not cover all aspects of the toolkit. Also note that the scenarios include elements that may not be implemented during the current project. It is e.g. not foreseen that the SHUTTLE toolkit will be in use at non-specialised police laboratories during the project. Also, the

implementation of a national or international database is not yet planned. However, the SHUTTLE toolkit to be developed should be prepared for these features

Scenario 1 Revenge: An unknown man is found dead in a quiet, residential area late in the evening. His clothing is recovered and taped by the police to collect microtraces. The tapes are analysed in the next hours by the SHUTTLE microscope that has been acquired by the police station. The police laboratory worker is not specialised in trace evidence, but has been trained to use the SHUTTLE microscope. The images are automatically saved in a national database, and a trace evidence examiner in the national forensic laboratory evaluates the data. Many pieces of glass are found on the clothing. Most of these are so small that they can hardly be seen by bare eye. Also, many black fibre traces have been recovered from the man's coat. The origin of these fibres is unknown, but their location and distribution indicate that they originate from an attacker. The police hypothesises that the incident may be related to a burglary a few blocks from the place where the victim was found. Policemen recover shards of glass originating from the broken window. During this investigation, they also note the black sweater of the inhabitant. The tapes, shards and the sweater are all sent to the forensic lab for further study. The analyst isolates a number of glass particles from the tapes: the SHUTTLE toolkit can *classify* glass, but not *discriminate* between glass from different sources. Isolation is also however straightforward, as the coordinates of the particles are stored in the dataset acquired by the police. Some reference fibres ('known material) from the sweater are also analysed by the SHUTTLE toolkit. The analyst compares the properties of the fibres from the sweater and those on the tapes, and finds they match in all investigated aspects. In addition, glass comparison also results in a match. Confronted with this information, the owner of the sweater admits that he chased a burglar that had entered his house, caught him, and kicked him until he collapsed.

Scenario 2 Dark matter: A woman is stabbed in a racially motivated attack in a shopping mall. The attack, caught on CCTV, lasted less than a second and did not involve any direct contact between the victim and the attacker. The CCTV footage leads to the arrest of a suspect within a few hours. The knife, found on the crime scene, the clothing (sweater, trousers) of the suspect, and tape lifts from the suspect's hands are sent by courier to the forensic lab. In the laboratory, the clothing is taped. Also, the microtraces found on the knife are transferred to tape. All tapes (knife, suspect's clothing and hands) are analysed by the SHUTTLE microscope.

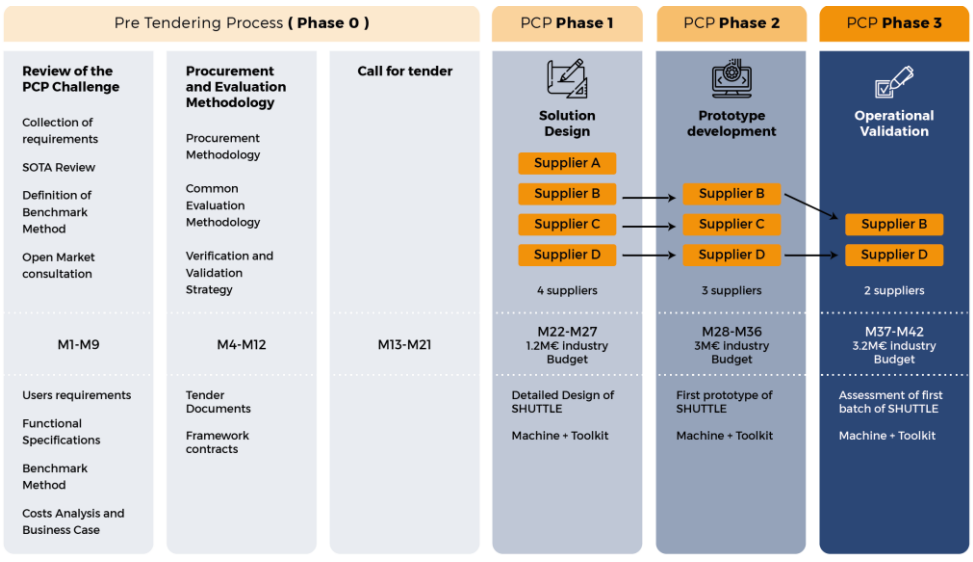
This analysis shows that the hands of the suspect contain several polyester fibres with an intense dark colour. Identical fibres are found on the handle of the knife. A European wide database search for these fibres reveals that similar fibres have been found in a glove that was analysed by a different SHUTTLE microscope in an unrelated case elsewhere in Europe. It is hypothesised that the suspect wore gloves during the attack but discarded them afterwards. Instantly, policemen search the road from the shopping mall to the suspect's home. In a trash can, two gloves are found. These are taped and analysed by the SHUTTLE toolkit. Between the many fibres on the tapes, the SHUTTLE toolkit locates small spots that are classified as blood. The analyst cuts out the area of the glove where the blood traces originated from. DNA analysis reveals a profile matching that of the victim.

Scenario 3 Casual encounter: In a case investigation, the suspect and the victim are neighbours and may have a legitimate contacts in the hours before the victim was killed. Due to these earlier contacts, it becomes of paramount importance to discriminate the trace distribution after the

possible legitimate encounter and an attack. The forensic expert asks forensic students of a national high school to carry out reconstructions. The students reproduce the scenarios put forward by the suspect and by the prosecutor. During these tests, the students wear highly fluorescent clothing to facilitate easy analysis. After the tests, tape lifts of the clothing are taken and analysed by the SHUTTLE toolkit present at the high school. The fluorescence enables quick and easy classification of the transferred microtraces. Within 30 days, the students report on the distribution of fibres traces following a fight and a casual encounter (as described by the suspect). The images provided by the students, created using the SHUTTLE toolkit, clearly show where transferred fibres can be expected. The forensic expert compares these images with the distribution of fibres found in the case and concludes that the trace distribution is consistent with a legitimate encounter, but not with the scenario put forward by the prosecution.

4. Process and timeline

The SHUTTLE project started in May 2018. During the first months of the project, the consortium members will define the requirements for the SHUTTLE toolbox. In November 2018, the consortium will organise an open market consultation to connect with relevant companies to probe industry interest and be informed on the state-of-the-art. These will be published in a tender around June 2019. Received tenders will be reviewed by the consortium and a number of companies will be awarded a contract (January 2020) to produce a concept design, consisting of detailed design specifications of hardware and software. The providers of the most promising concept designs will be invited (November 2020) to build a prototype and possibly a larger range of products. Please note that the mentioned dates are according to current planning and might be adjusted due to circumstances.



5. Get involved

If you want to obtain updates on SHUTTLE, please let us know on shuttle-tender-contact@eurtd.com If you think your company can produce (a part of) the SHUTTLE toolkit, please join the Open Market Consultation day. More information on https://www.shuttle-pcp.eu.