Institution: Abertay University

Unit of Assessment: 12 - Engineering

Title of case study: Improving forensic practice and policy to maximise fingermark recovery and visualisation

Period when the underpinning research was undertaken: 2011 – 2020

Details of staff conducting the underpinning research from the submitting unit:

Names:	Roles (e.g. job title):	Periods employed by submitting HEI:
Dr Kevin Farrugia	Lecturer	2014 – 2019
Dr Joanna Fraser	Lecturer	2006 – 2019
Dr Ben Jones	Senior Lecturer	2015 – present
Dr Keith Sturrock	Lecturer	1984 – present

Period when the claimed impact occurred: 2014 – 2020

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact

Our research on improving forensic fingermark (latent fingerprint) recovery techniques has had impact in three specific areas:

1. **Supported UK Home Office and police forces**: Our research on fast and effective fingermark recovery techniques that enable evidence to be collected optimally has informed policy documents and research strategies published by the UK Home Office, Interpol and the International Fingerprint Research Group. These documents form the basis for operational practice.
2. **Identified greener products**: Our collaboration with industry has identified more environmentally friendly formulations to recover fingermarks; which are now part of The UK Government's Defence Science and Technology Laboratory (Dstl) guidance to UK police forces.
3. **Stimulated new markets**: Our development of new processes for fingermark detection on difficult surfaces have enabled our industry partners to use these findings to inform their recovery process, and to enhance product marketing and uptake of optimum techniques in the sector.

2. Underpinning research

In any crime scene it is important to maximise evidence recovery both at the scene and from items transferred into a forensic laboratory. The underlying material on which evidence is found has a strong influence on the effectiveness of fingermark development techniques. Different techniques are therefore required for paper, polymer or metal, but there is also significant variation of the substrate within these categories (for example, the polymers PVC, polypropylene, and low density polyethylene behave differently). Complications to the recovery process arise when multiple types of evidence are found in combination on the same substrate, and factors such as the presence of contaminants, the age of the mark, and exposure to weather can impede recovery of the evidence.

Research at Abertay has developed fingermark (latent fingerprint) development techniques and operational parameters to maximise crime scene evidence recovery where fingermarks are present. Specifically, our work contributes to identifying the optimal techniques for fingermark development, speeding up visualization processes and developing a sequential order for treating

multiple types of evidence to maximise evidence recovery. Our research examines fingermark development techniques including cyanoacrylate fuming (CAF), powder suspensions and vacuum metal deposition (VMD). We have investigated the interactions among surface type, development technique and environment, and developed processes for mark development on complex substrates such as fabrics, thermal paper, and polymers.

We have demonstrated a one-step CAF fluorescent process to remove the dyeing stage from the standard procedure, in a bid to improve the rate of detection of fingermarks as well as to reduce processing time and space, speeding up detection from over 24hrs to 30mins. Furthermore, the use of solvents such as those used in the dyeing stage of the standard process can be detrimental to other types of evidence such as DNA and inks. We have shown that for fingermark recovery from plastic bags the atmospheric/ humidity cyanoacrylate process is superior to vacuum cyanoacrylate fuming **[3.1]**. We have demonstrated that the one-step process is compatible with techniques for recovery of body fluids and is an effective replacement for the two-step process on a range of surfaces, as well as highlighted the limitations of use **[3.2]**. These studies have initiated further investigations by other research groups and supported the development of one-step products with industry.

A number of techniques for the development of latent fingermarks use chemicals or solvents (e.g. HFE-7100, Triton X-100) that are harmful to the environment. The EU and UK banned some of these fluorinated chemicals (e.g. EU Regulation 517/2014 and House of Commons HC469) in January 2021. In response, replacement solvents were required to ensure that essential forensic processes could still take place. Our recent studies, in collaboration with the UK Home Office and industry, have resulted in alternative fingermark development formulations that are less harmful to the environment and are better or as effective as the current recommended techniques for developing marks with minimal interference **[3.3**, **3.4]**. Our work on developing powder suspension techniques demonstrates the key particle size fraction responsible for fingermark development **[3.4]**.

Research into developing fingermarks from difficult surfaces such as fabric has provided important findings, including that ridge detail is recoverable from fabric using VMD **[3.5]**. This provides information for targeted DNA analysis and potential corroboration of witness statements as it enables differentiation between actions such as: grabbing or pushing the victim; picking up or smothering with a pillow. We also demonstrated the use of VMD on polymer banknotes and thermal paper, showing that the optimum visualisation conditions are dependent on the substrate material, and explained this in terms of the time-dependent behaviour of the fingermark on the surface **[3.2, 3.6]**.

3. References to the research

3.1 Farrugia, K. J., Fraser, J., Friel, L., Adams, D., Attard-Montalto, N. and Deacon, P. A comparison between atmospheric/humidity and vacuum cyanoacrylate fuming of latent fingermarks. Forensic Science International, 2015, 257, 54–70. https://doi.org/10.1016/j.forsciint.2015.07.035

3.2 Sherriffs PB**, Farrugia KJ, Fraser JM, Jones BJ**. The optimisation of fingermark enhancement by VMD and Lumicyano™ on thermal paper. Science & Justice 2020, 60(2),160-168. http://doi.org/10.1016/j.scijus.2019.10.004

3.3 Olszowska, I., Deacon, P., Lindsay, M., Lesniewski, A., Niedziólka-Jönsson, J., **Farrugia, K.J**. An alternative carrier solvent for fingermark enhancement reagents, Forensic Science International, 2018, 284, 53-64. https://doi.org/10.1016/j.forsciint.2017.12.012

3.4 Downham RP, Sears VG, Hussey L, Chu B-S, **Jones BJ**. Fingermark visualisation with iron oxide powder suspension: The variable effectiveness of iron (II/III) oxide powders, and Tween® 20 as an alternative to TritonTM X-100. Forensic Science International, 2018, 292,190-203. https://doi.org/10.1016/j.forsciint.2018.09.012

3.5 Knighting S**, Fraser J, Sturrock K**, Deacon P, Bleay S, Bremner DH. Visualisation of fingermarks and grab impressions on dark fabrics using silver vacuum metal deposition. Science & Justice, 2013, 53 (3), 309–14. https://doi.org/10.1016/j.scijus.2013.01.002

3.6 Popov KT, Sears VG, **Jones BJ**. Migration of latent fingermarks on non-porous surfaces: observation technique and nanoscale variations. Forensic Science International, 2017, 275, 44–56. http://doi.org/10.1016/j.forsciint.2017.02.015

4. Details of the impact

4.1 Home Office and Police

Abertay work on VMD, one-step CAF techniques, and powder suspension development processes has made an essential contribution to the development of the Fingermark Visualisation Manual (FVM) 2014 **[5.1]**, the Fingerprint Source Book (FSB) v2 2017 **[5.2]**, and subsequent Defence Science and Technology Laboratory (Dstl) updates (2019) **[5.3]**. These are produced by the UK Home Office as the authoritative documents for fingermark enhancement in the UK and are recognised internationally in publications by Interpol and the International Fingerprint Research Group **[5.4]** as guides on fingermark enhancement.

> "*Our work provides support and recommendations for police force and forensic service providers, and reflects local and international priorities, developed through collaboration with forces and supplier networks. Our key outputs include the Fingermark Visualisation Manual, the Fingerprint Source Book and regular updates to protocols. These documents are the standard reference for police forces and forensic providers in the UK and beyond in their laboratory work and are key for validating their processes for ISO17025 accreditation, which is a requirement from the Forensic Science Regulator, and key to quality of science for justice and public trust in forensic science… The team at Abertay have contributed significantly to the development of fingermark visualisation techniques for operational use"* UK Government's Defence Science and Technology Laboratory **[5.5]**

Abertay's specific contributions to these authoritative documents **[5.1, 5.2, 5.3]** includes our research on fingermark recovery via one-step CAF, reducing operational time and validating the route to replace the more cumbersome two-step method, our work on powder suspensions and using Vacuum Metal Deposition (VMD) to enhance marks on challenging surfaces and providing contextual information for practitioners.

In the FSB **[5.2]**, six Abertay outputs (including **3.1** and **3.5**) contribute to Chapter 3: Chemical and physical processes. Our pseudo-operational trials, including CAF research, have been cited as the only examples of this kind of trial in this area, and are the basis for operational use internationally.

> *"This* [Abertay's] *substantial body of work helped lay the groundwork for development of the technique as an operational process, and validate its use for forensic providers."* Editor of the Fingerprint Visualisation Manual **[5.5]**

> *"*[Abertay research] *has been inspiring for many. E.g. the French Gendarmerie, today one of our largest user of Lumicyano, has clearly developed its user protocol based on Kevin [Farrugia]'s work"* Managing Director, Crime Scene Technology **[5.6]**.

Our powder suspension research presents modified processes for fingermark visualization in light of changing materials and legislation, ensuring police forces and forensic providers can maintain operational capability. Our work in this area was issued to forensic science providers across the UK and internationally by Dstl in 2019 as part of an official update to guidance on best practice from UK Government **[5.3, 5.6]**. Our research is highlighted in the FSB as the body of work that shows VMD is now the optimum technique for developing fingermarks on fabrics, following operational withdrawal of an unsafe technique at the turn of the century. The

VMD developed material also shows flexion creases and impression shapes that provide context giving added intelligence in forensic investigation **[5.1, 5.5]**.

4.2 Greener products

4.2.1 Dstl and Triton X-100: Our research on powder suspension **[3.4]** has provided an alternative to Triton X-100, with demonstrated effectiveness essential to maintain operational capability. Triton X-100 is a detergent routinely used in forensic laboratories. From 4th January 2021 it has been illegal to sell Triton X-100 in the European Economic Area unless an authorisation is granted. This is because one of its key ingredients is on the Candidate List of Substances of Very High Concern as defined in article 57 of the REACH Regulation (European Commission).

In partnership with Dstl (previously the Home Office) Abertay undertook research on the reformulation of powder suspension **[3.4]** with environmentally friendly components and presented a specification of powder size to ensure effectiveness. We have presented a replacement formulation, utilising Tween 20 instead of Triton X-100 and in doing so, proved it is possible to remove the need for environmentally hazardous formulations.

> "*We have identified the importance of finding alternatives to solvents with global warming potential (GWP), in line with upcoming legislation, in order to maintain operation capability. To aid this effort, the Abertay team have worked to explore alternative carrier solvents with significantly GWP for fingermark enhancement.*
>
> *Dr Jones has worked with the Home Office on the development of powder suspension formulation, to replace Triton X-100 (banned for production and use in Europe from 2021). His contribution was critical in ensuring the efficacy of the new formulation, through specification of powder morphology. This new formulation was released as part of our updated guidance in 2019.*" UK Government's Defence Science and Technology Laboratory (Dstl) **[5.5]**.

Details of our findings **[3.4]** were distributed to police forces and researchers in the UK and internationally via Dstl in March 2019 **[5.3]**. Updates by Dstl regarding the information in the FVM are used by police forces to improve and validate their processes. This portfolio of updates not only maintains essential operational capability but includes resilience via validation of a fundamental basis of formulations.

4.2.2 Honeywell and Solstice: Several techniques for the development of latent fingermarks used up to 2020 included chemicals or solvents that are harmful to the environment. Hydrofluoroethers (HFEs) were typically used in the sector as suitable replacements for CFCs in fingermark development formulations in an attempt to limit ozone depletion. However, another problem with global warming potential (GWP) ensued, resulting in a potential restriction of certain solvents by the UK and EU. Abertay collaborated with Honeywell chemicals to demonstrate the effectiveness of a new solvent, Solstice PF **[3.3]**. The solvent has been shown to be non-ozone depleting, has a very low GWP and is as effective as the HFE-solvents in the previous formulations **[5.7].**

4.3 New Markets

4.3.1 Crime Scene Technology: Abertay research investigating the one-step CAF process Lumicyano is fundamental to the development and marketing of this disruptive technology. The work by Abertay has been used to help market the product by Crime Scene Technology (CST) to their international customer base, including French, US, and German police:

> "*Since many years C.S.T and the University of Abertay, and specifically Kevin Farrugia and his team have developed a strong scientific relationship …Kevin was the first academical forensic scientists to understand the pertinence and the disruptive nature of the technology. He has carried out several studies on Lumicyano and has explored the various potentials of usage of the technology. Many times we had the opportunity to*

share with other forensic scientists and operational forces the results of the work carried out by Kevin and his team... It is absolutely clear that Kevin Farrugia's work on Lumicyano has been an asset for the commercial development of the technology." Managing Director, Crime Scene Technology **[5.6]**.

4.3.2 West Technology Forensics Ltd: Our research, demonstrating that it is possible to use VMD to obtain contextual information from fingermarks on fabrics (such as determining if a pushing/grabbing action has been used to produce a mark) **[3.4]** and the benefits of VMD on difficult substrates such as thermal paper and banknotes **[3.2]**, has been used by the company West Technology Forensics Ltd (West Tech) to market their VMD systems in the UK and internationally:

"*Over the past five years we have transformed the market of vacuum metal deposition (VMD), previously regarded as an out of favour, expensive technique and found in very few laboratories, the market has expanded to >8,500,000 GBP or > 150 instruments.*

We have worked with the team at Abertay University to investigate the behaviour of fingermarks and how they interact with our VMD technique and collaborated to explore difficult surfaces such as thermal paper. We have made use of Abertay's work showing the operational effectiveness of VMD on fingermarks on troublesome materials such as fabrics and polymers.

We have used to the research from the Abertay University team to help develop our work and market our technique. In marketing an alternative forensic technique to police forces and forensic providers, it is crucial to show the effectiveness of development, ridge detail and contrast that can be achieved on a range of surfaces. Abertay's work identified VMD as the best potential safe technique for fingermarks on fabrics and showed the possibilities for forensic investigations to gather more intelligence from these marks. Abertay's independent research has been crucial in helping us accelerate the expansion of the use of VMD globally" Managing Director, WestTech **[5.8]**

5. Sources to corroborate the impact

5.1 Bandey, H. L., Ed. Fingermark Visualisation Manual; Home Office Centre for Applied Science and Technology: Sandridge, UK, 2014.

5.2 S. Bleay, et al., Fingerprint Source Book v2.0, Home Office Centre for Applied Science and Technology, UK, 2017. https://www.gov.uk/government/publications/fingerprint-source-book-v2

5.3 Dstl Fingermark Visualisation Newsletter, March 2019, Defence Science & Technology Laboratory, Publication No. DSTL/PUB113778. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/895971/2019_Mar_Fingermark_Visualisation_Newsletter_3_v1.0_Mar19.pdf

5.4 Bécue, A.; Champod, C. Fingermarks and other impressions 2013-2016, 18th INTERPOL International Forensic Science Managers Symposium Review Papers, Identification Sciences, pp 617–696. https://www.interpol.int/en/content/download/13472/file/INTERPOL%2018th%20IFSMS%20Review%20Papers-2016.pdf

5.5 Testimonial from Dr Helen Bandey, Technical Lead for Fingermark Visualization, Defence Science & Technology Laboratory. DSTL/DOC128999

5.6 Testimonial from Jerome Comar, Managing Director, Crime Scene Technology.

5.7 Testimonial from Alberto Malerba, Senior Marketing Manager, Honeywell Fluorine Products.

5.8 Testimonial from Ian Harris, Managing Director, West Technology Forensics Ltd.