# Fingermark Visualisation Newsletter

**March 2017**




**CAST** is pleased to issue the latest Fingermark Visualisation Newsletter to update you on activities that the fingerprint team at CAST has been involved in over the past year.

2016 was a milestone year for fingerprints within CAST, marking 30 years of comprehensive instructions and guidance on the recovery of fingermarks via the 'Manual of Fingerprint Development Techniques' (1986 to 2014) and more recently the re-branded 'Fingermark Visualisation Manual' (2014 to current). Although CAST has undergone many organisational changes during this time period (previous names include SRDB, PSDB, HOSDB*), it has always maintained an active research and development programme that has ensured the information in the Manual is fit for purpose and supported by robust scientific data. This continuity and scientific rigor has proved even more valuable in recent years as processes within laboratories become accredited to the ISO 17025 standard. The level of information ensured that each laboratory does not have to fully validate each process, leading to significant savings.

It is interesting to reflect on the early years of the Manual. Back in 1986 it was ground-breaking in its approach; providing, for the first time, recommendations in the form of a series of flow charts which guide the user to choose the best processes for each case and precise details on how to carry out each process. Terry Kent, head of fingerprints (1980 to 2004) and the brains behind the original concept, gives insight into the difficulties and opportunities at that time and states:

'"Until the manual was published, all Home Office reports and guidelines, on new or modified techniques, were issued as rather boring typewritten separate reports sent out to Chief Constables. These often got stuck in a drawer in a boss's desk. Collating the advice into a comprehensive manual, designed from the outset to be used in the laboratory and incorporating flow charts, was a major step forward for the burgeoning fingerprint laboratories which were becoming established in most forces.

"The text and charts were produced using what was then the latest WYSIWYG Macintosh computer, new in 1984, and laser printer, new in 1985. Much to the surprise of the printers we were able to supply all text and artwork as 'camera-ready copy', by-passing the need for typesetting. Certainly the first Home Office document to be created that way and probably a government first.

"It was very favourably accepted as the guide for UK forces and rapidly became known throughout most of the English-speaking world with many overseas sales."

Although the research community strive to provide improvements via novel scientific methods (some of which are described in this newsletter), it is always a surprise to the uninitiated how much thought and effort is required to simply stand still and **only** maintain a level of service. Even throughout this newsletter – a snapshot in time – there are articles relating to maintaining a service level that have been impacted by issues such as substrate changes (polymer banknotes, painted walls) or chemical supply (Physical Developer).

The Manual is now, as it was back in 1986, still recognised as the leading publication for practitioners across the UK and across many countries worldwide.


*Fingerprint staff past and present.*
*Left to right (back): Simon Walker, Vaughn Sears, Terry Kent, Rory Downham, Stephen Bleay, Sheila Hardwick, Juliet Baker, Christine Townsend, Rob Townsend, Nick Murray.*
*Left to right (front): Amelia Thomas-Wilson, Helen Bandey, Lesley Fitzgerald, Rob Luck, Laura Hussey*

* Scientific Research and Development Branch
Police Scientific Development Branch
Home Office Scientitifc Development Branch

# FINGERMARK VISUALISATION MANUAL

Editor: Dr Helen Bandey
(**Helen.Bandey@homeoffice.gsi.gov.uk**)

## Future update


Although it only seems like yesterday since the FVM was published, there is now a significant body of new and updated information that needs to be incorporated into a new edition. CAST will now scope the work required to produce an updated manual and agree the timescales for the update with stakeholders. We will keep you informed on progress with this activity.

Since publication of the first edition in 2014, the editor has encouraged users to feedback improvement suggestions relating to any aspect of the FVM including design, functionality, fitness-for-purpose, future vision etc. This information, in part, will help CAST to ensure that the next version continues to meets the requirements of operational policing where possible. Your views **are** important to us, so please continue to send comments to the editor.

Highlights of the next edition will include the findings from many of the research and development studies reported in these newsletters such as:

- extensive updates to charts and process instructions for the inclusion of Indandione as a category A process;
- updated information on how to process UK polymer banknotes;
- updated formulations and process instructions for Physical Developer;
- promotion of Natural Yellow 3 to category A for finding grease marks on dark items;
- updated information on MALDI-MS.

You too can contribute. Appendix 1 of the FVM has a number of examples of operational situations which demonstrate how plans have been generated after consideration of all the relevant facts, constraints and limitations. More examples would further demonstrate the reasoning behind effective planning. Please send information on case studies, in a similar format to that already published, to the editor for consideration for inclusion.

For technical enquiries relating to the FVM, please contact the editor or another member of the CAST fingerprint team (see back page for contact details). FVM sales enquiries should be directed to Clare Polley, Official/Libraries Sales Manager, TSO (**clare.polley@tso.co.uk)**.

Service Manager: Vaughn Sears
(**Vaughn.Sears@homeoffice.gsi.gov.uk**)

# In-house studies

## Indandione – the new DFO? – update

In the February 2016 newsletter, CAST reported promising results that may lead to the replacement of DFO with Indandione pending additional validation studies. We are pleased to report that CAST has completed the research and development stages of the Indandione process for the visualisation of fingermarks on porous surfaces. This has resulted in a different formulation which supersedes that currently in the FVM.

We have also carried out an extensive pseudo-operational trial of the three amino acid reagents (DFO, Indandione and Ninhydrin). DFO was compared to Indandione in a trial involving 1000 realistic paper and cardboard samples (500 samples each). Of these samples, 864 (half treated with DFO and half with Indandione) were then sequentially treated with Ninhydrin to see if there was any added benefit.

Each sample was treated with the reagent and any developed marks that had an area of clear ridge detail greater than 64 $mm^2$ were counted and photographed. It was found that the new Indandione formulation developed 1.6 times as many marks as DFO. It was also found that Ninhydrin developed a significant number of extra marks after both DFO and Indandione.
(See graph on the next page).

Where appropriate, CAST would normally carry out a comparative operational trial with help from one or more police force laboratories to ensure that the findings are replicated on casework material. It is reasonable to expect that marks deposited during the action of carrying out a crime may differ to those generated during laboratory trial work or through everyday handling of items (such as those treated in a pseudo-operational trial).

Over the years, CAST has seen first-hand the benefits of such trials including:

- previous amino acid reagent operational trials have shown up to a 14% difference between laboratory trials and performance on real world samples;
- failure to run an operational trial resulted in processes, which had been introduced to laboratories around the world, being withdrawn after it was found they were less effective than laboratory trials indicated.

In this study, when considering replacement of a mainstream process (in this case DFO) with a new process (in this case Indandione), an operational trial is most important. However, additional constraints on the use of casework for validation have meant that CAST is yet to establish and agree a protocol for doing this.This should not stop individual laboratories from doing this final stage of validation themselves.

For that reason CAST would like to share the new information, but stress that if Indandione is introduced into operational work, the organisation will need to monitor effectiveness closely to see that it is better (or at least matches) the previous effectiveness of DFO.

The FVM already contains an (almost) full process instruction for Indandione in Chapter 6. This will develop into a category A process instruction and move to Chapter 5. Although this can be followed as it stands, it should be noted that **there is a new formulation for Indandione** and it is as follows:

### Solutions

**Indandione Working Solution**

0.25 g 1,2-indandione
45 mL ethyl acetate
45 mL methanol
10 mL acetic acid
1 mL Zinc Chloride Stock Solution
1 L HFE7100

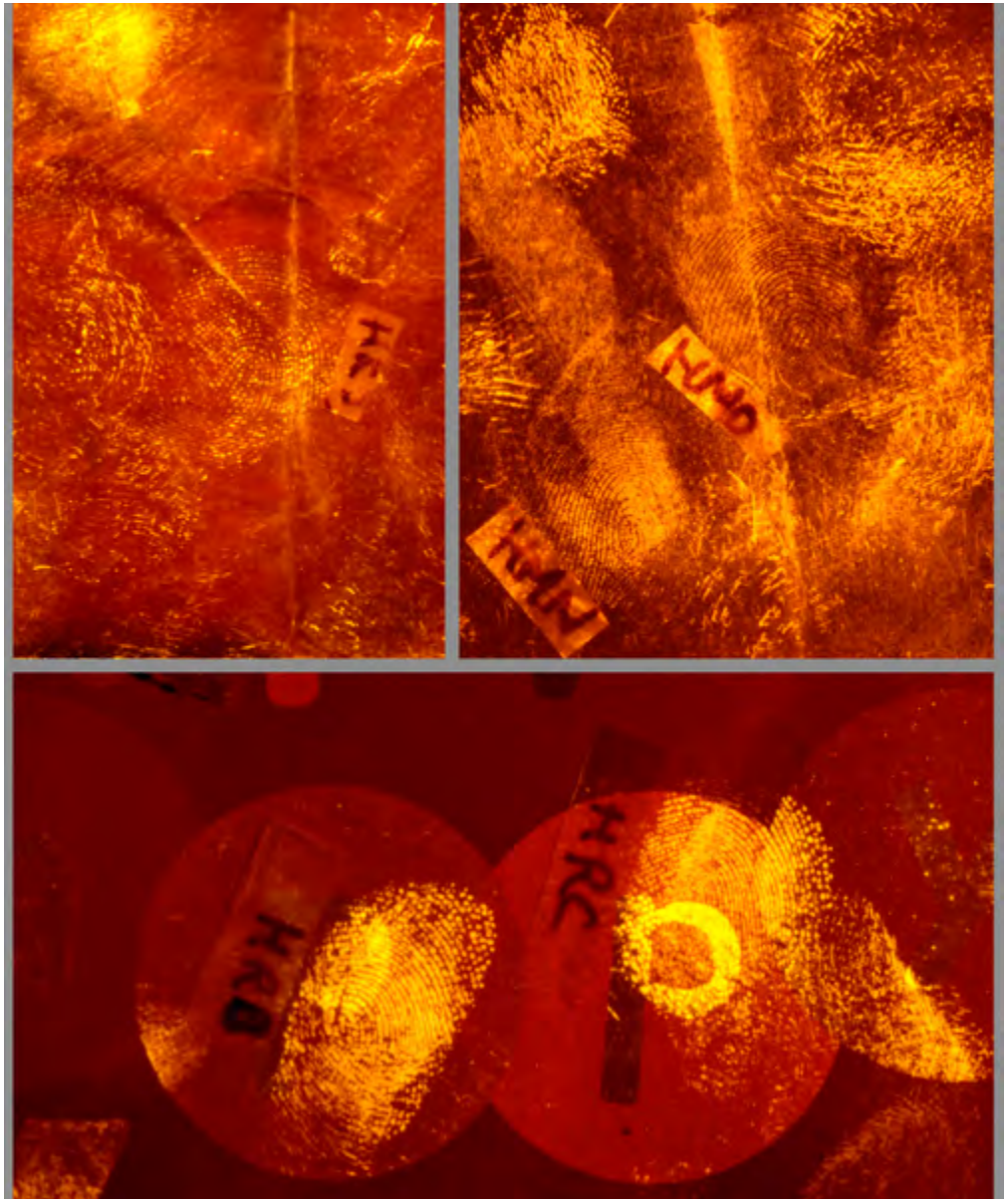
**Zinc Chloride Stock Solution**

0.1 g zinc chloride
4 mL ethyl acetate
1 mL acetic acid

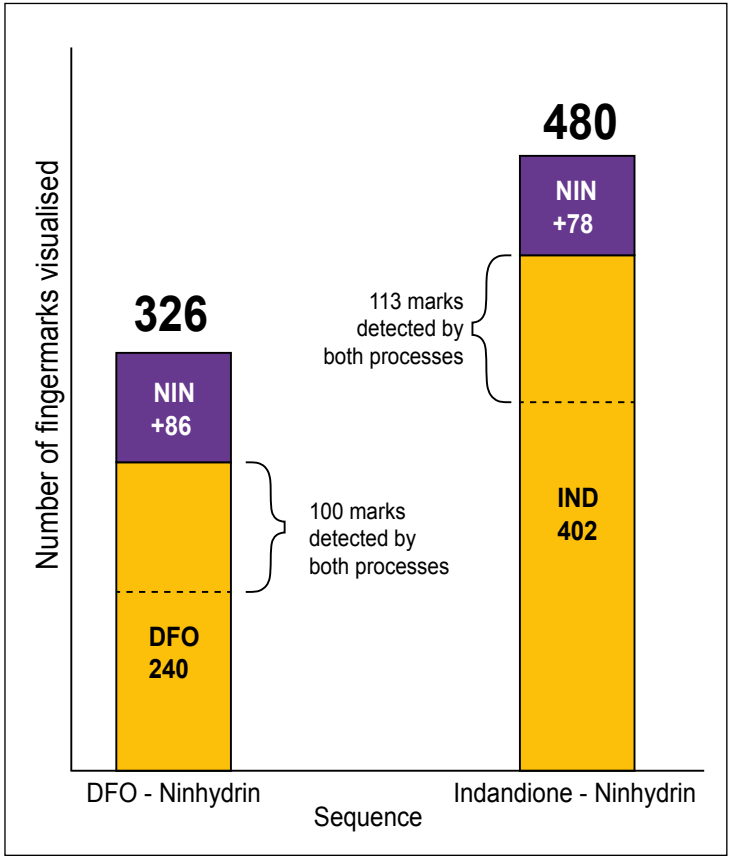
In addition, **the chemicals need to be added in the order given otherwise the solution is unstable and will go cloudy.**

After processing, the items are heated in a dry oven for 10 minutes at 100 °C. The fluorescence can be excited by a 532 nm laser, the blue/green Crime-lite® or other suitable high-intensity light source.

# RESEARCH & DEVELOPMENT



*Examples of typical indandione developed marks*




*Number of fingermarks visualised vs. sequence for pseudo-operational trial comprising of 432 porous items (varied) per sequence.*

# RESEARCH & DEVELOPMENT

## Physical Developer

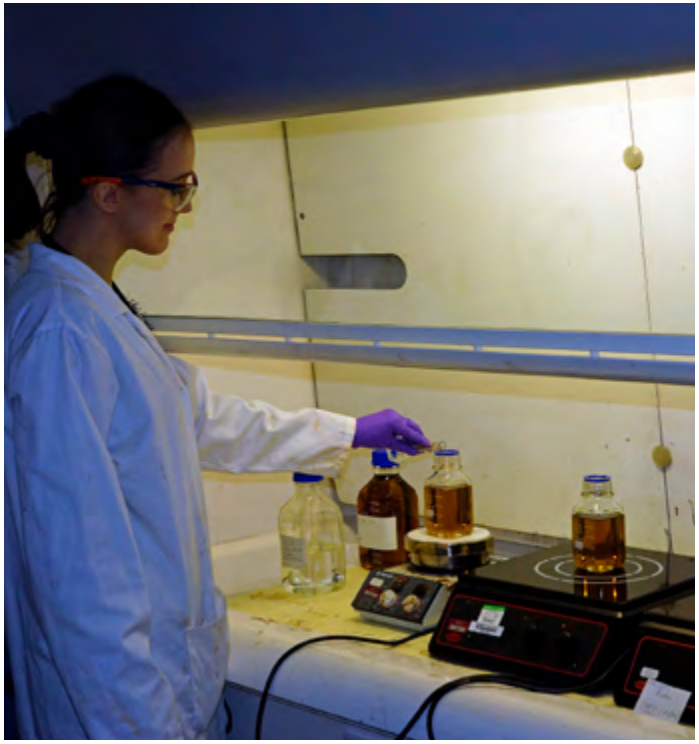
CAST is currently investigating the replacement of the two reagents within the stock detergent solution of Physical Developer. This solution is supplied to UK police forces by CAST and it contains n-Dodecylamine acetate and Synperonic N. CAST holds a stock of n-Dodecylamine acetate; the purity varies considerably from batch to batch so by purchasing a large batch CAST enables consistency of supply. The current stock is running low so a replacement batch of n-Dodecylamine has been purchased and is being tested for effectiveness.

*A failed alternative to Synperonic N has not kept the silver in solution and this has precipitated at the bottom of the bottle*

The second reagent in the stock detergent, Synperonic N, has been banned for use over a certain concentration (Physical Developer is far below this level) and as a consequence is no longer manufactured. Other countries switched to using Tween 20 as an alternative to Synperonic N. The solution is known to be more stable but, for unknown reasons, it has to be stored prior to use for a number of weeks after preparation for maximum effectiveness. Experiments at CAST will investigate further.

Once a replacement stock detergent has been validated, the FVM process instruction will be updated (at the first available opportunity). In the interim, CAST will be sending out only 500 mL of the stock detergent to each force to limit supply. Also, the reagents have a long shelf life so please do not dispose of stock detergent unnecessarily.

Expiry dates given in the FVM are only guidelines – chemicals are not good one day and degraded the next. We expect the solutions to last as long as the guideline. However, you always need to assure yourselves that any solutions are still working as expected as part of your ISO 17025 accreditation by implementing control measures that at least tell broad differences in solution effectiveness.



*Amelia Thomas-Wilson, Undergraduate placement student from Liverpool University preparing PD solutions in the CAST laboratories*

## Polymer banknotes – update

On the 13th September 2016, new £5 banknotes from the Bank of England entered circulation. The new notes are polymer-based, with layered treatments applied non-uniformly to the surface. They feature transparent windows, printed areas of varying detail (some of which are raised), and foil patches.

The currently recommended fingermark visualisation processes for paper-based banknotes were thought to be, and later (in preliminary testing) confirmed to be, unsuitable for the new substrate. Therefore CAST, in collaboration with scientists Dr Roberto King (Foster + Freeman Ltd) and Eleigh Brewer (West Technology Systems Ltd), investigated a wide range of typically non-porous processes for fingermark visualisation capability on the new notes, provided for the purpose by the Bank of England, in advance of their introduction.

The range of physical and chemical fingermark visualisation methods explored included category A processes from the FVM alongside other more recently developed techniques (see table). The testing identified multiple processes that offered reasonable fingermark visualisation capability, with the most effective indicated to be fpNatural® 2, Multi-Metal Deposition, Wet Powder™ black, iron oxide Powder Suspension and black magnetic Powder, when observed under primary viewing conditions.

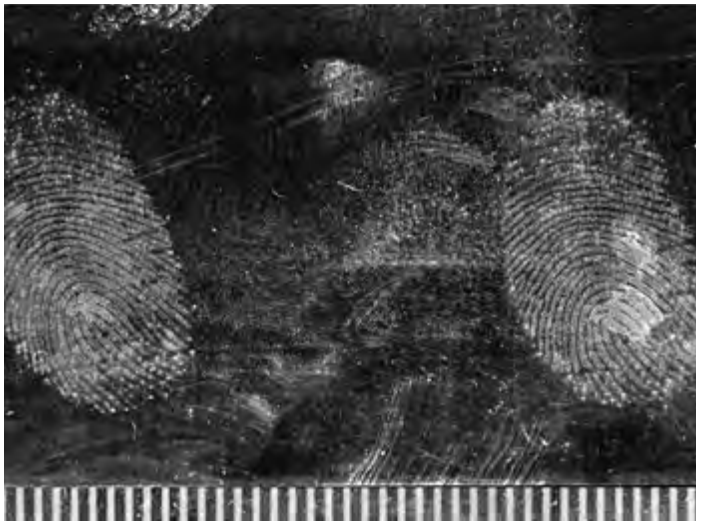
For most processes, developed marks were difficult to distinguish against the highly patterned and coloured areas of the £5 note. For this reason

| Processes compared | Primary viewing conditions |
|---|---|
| Black magnetic Powder | White light |
| fpNatural®1 | Fluorescence |
| fpNatural®2 | Fluorescence |
| Iron oxide Powder Suspension | White light |
| Lumicyano™ | Fluorescence |
| Multi-Metal Deposition | White light |
| PolyCyano UV | Fluorescence |
| Small Particle Reagent | White light |
| Superglue Fuming | White light |
| VMD1 (gold-zinc, then silver) | White light |
| VMD2 (silver-zinc) | White light |
| Wet Powder® black | White light |
| Wet Powder® white | White light |

*Fingermark visualisation processes used in the polymer banknote trial*

the work also considered imaging techniques that could suppress or remove the interfering background effects, including infrared reflection and lifting the developed marks off the surface using gelatin lifting media. With the additional benefit of these techniques taken into consideration, the aforementioned processes remained amongst the most effective overall.


*Fingermarks visualised with Multi-Metal Deposition, as viewed under white light (above) and from a gelatin lift scan (below)*



# RESEARCH & DEVELOPMENT


*A fingermark visualised with Powder Suspension, as viewed under white light (left), via reflected infrared (middle) and from a gelatin lift scan (right)*

It should be acknowledged that fpNatural®2 was developed for fingermark visualisation on substrates with challenging backgrounds. Fingermarks treated with fpNatural®2 fluoresce in the infrared under infrared excitation. These fluorescence conditions ('primary viewing' for the process) provided highly effective background interference removal. However, specialist excitation and viewing equipment is required.

It is important to highlight that the Superglue Fuming and Vacuum Metal Deposition (VMD) methods incorporated in the study were found to recover noticeably fewer fingermarks than the most effective processes (following the use of both primary and secondary viewing approaches). Superglue Fuming was found to be mostly ineffective on Australian and Canadian banknotes in other published research, although it was shown to be an effective primer for VMD (this Superglue Fuming - VMD sequence has not yet been explored on the £5 polymer UK notes).

The experimental work conducted on the £5 banknotes before their introduction enabled initial guidance to be given to UK Law Enforcement Agencies (LEAs) on the day that the £5 notes entered circulation (CAST publication no. 116/16 'Fingermark Visualisation on £5 (Bank of England) Polymer Banknotes, initial guidance' ).

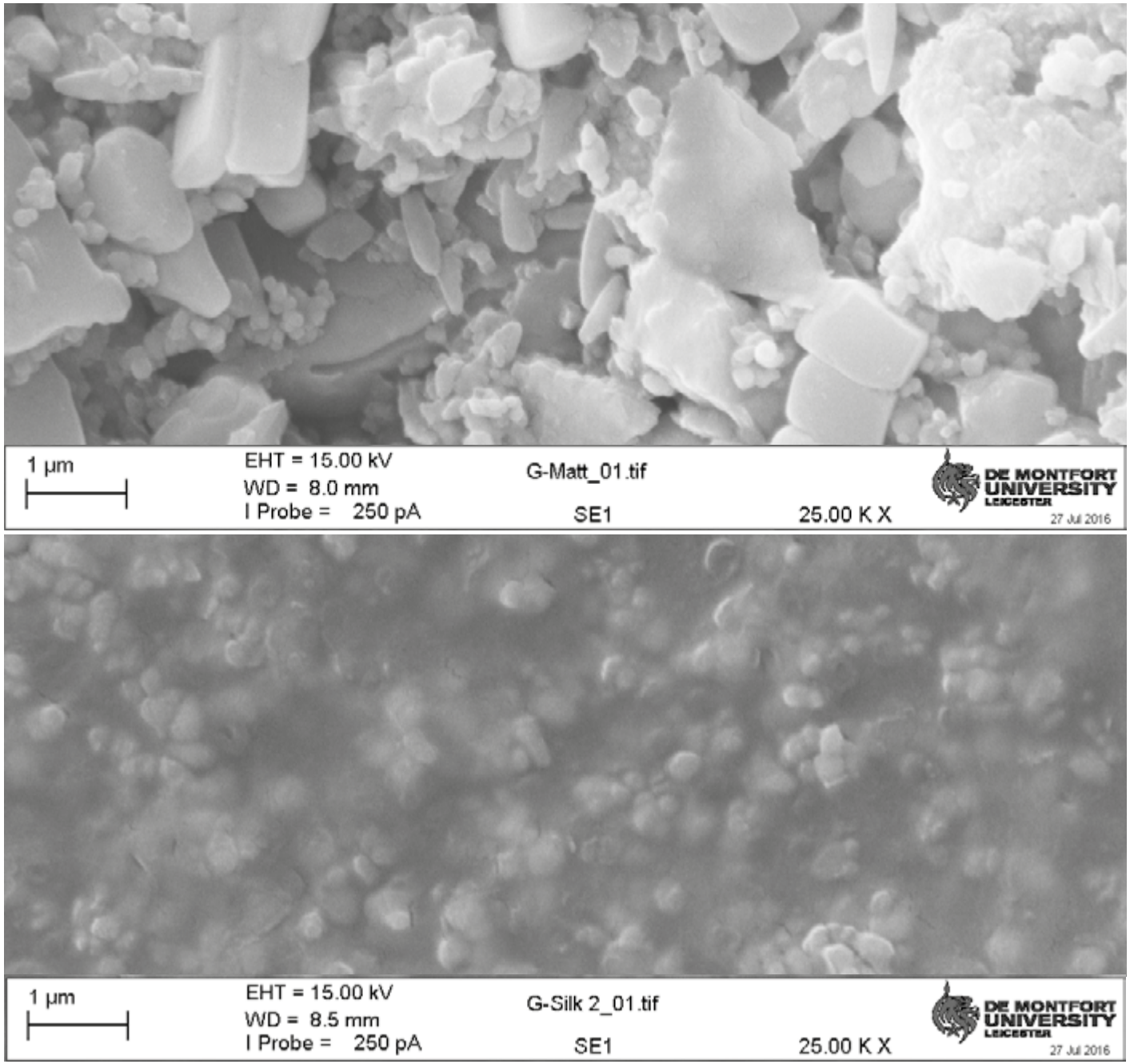
This work has also been written up formally and submitted to a journal for peer review.

CAST plans to conduct similar studies on the new polymer £10 banknotes prior to their introduction in 2017. Once complete, the polymer currency chart in the FVM (Chart 1.7) will be updated to reflect the new findings. The maturity level will increase, although there is still limited validation data on parameters such as process sensitivity or process effectiveness as the notes wear in normal circulation. CAST welcomes feedback on any aspects of fingermark visualisation on polymer banknotes or the guidelines.

# Studies directly supported by CAST

## Fingermarks on Walls

CAST is providing support, in the form of industrial supervision, for a PhD study at Anglia Ruskin University (ARU). Jo Dawkins, previously a crime scene investigator (CSI), is a lecturer at ARU and is currently juggling her teaching commitments with her PhD studies which will advance the understanding and application of visualisation processes on walls coated with a range of modern paints. Preliminary work has included a survey of scientific support practitioners on current practices, and investigations into paint science and usage through discussions with leading DIY stores. Early experimental work indicates that the guidance currently given Chart 2.7 (matt-painted surfaces) in the FVM may be inadequate for modern paints. Further studies will include correlating process effectiveness with the surfaces' microscopic structure and investigating improved application methods for the best performing processes.






*Scanning electron microscope images of water-based matt paint (top) and silk paint (bottom) clearly showing the structural differences*

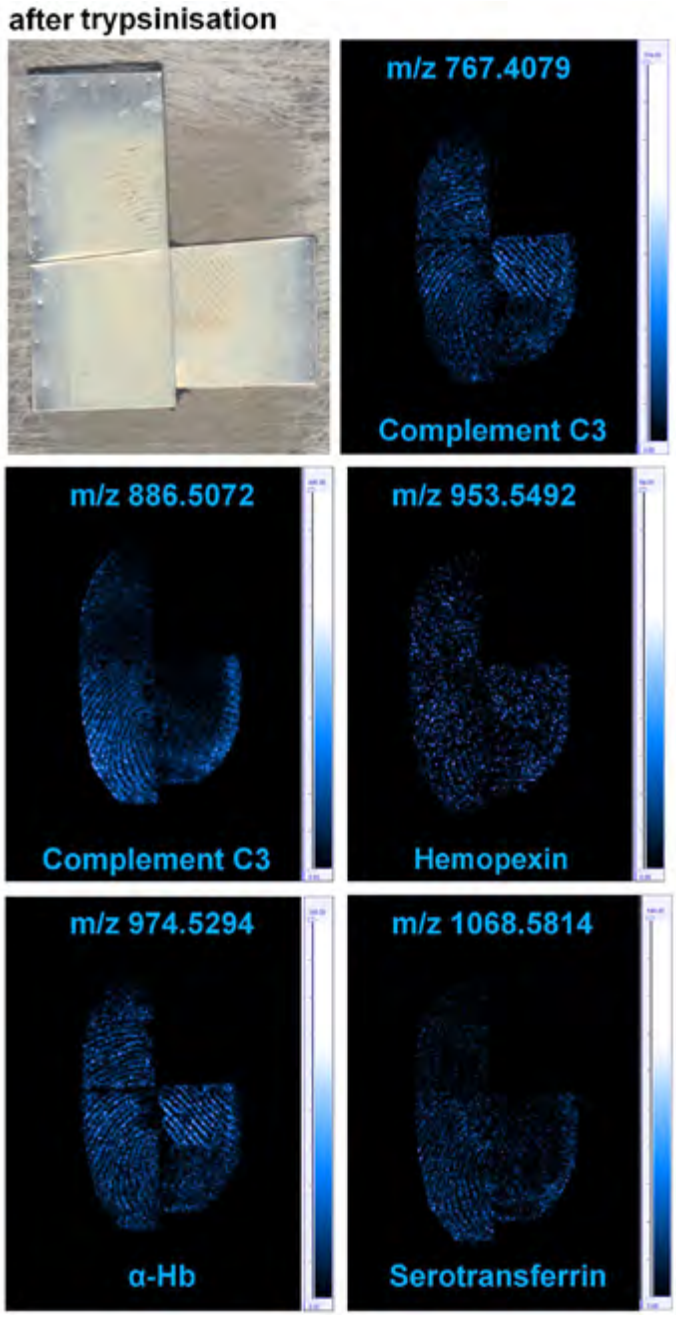
# RESEARCH & DEVELOPMENT

## Maximising evidence from blood and other body fluid contamination – update

In the last newsletter, CAST reported early findings from a match-funded PhD study at Sheffield Hallam University looking at specific detection of human blood in both untreated fingermarks and fingermarks previously enhanced with protein or amino acid reagents. The principal process technology being used is matrix-assisted laser desorption/ionisation – mass spectrometry (MALDI-MS) to both detect and visualise blood onto the fingermark ridge pattern. Infinite focusing microscopy has also been used to investigate the opportunity to distinguish marks in blood and examine the context.

We reported that the method has been shown to identify human blood on Acid Black 1 treated palm prints as old as nine years, as well as on over 30-year-old stains on fabric originally treated with Ninhydrin. It is also fit to distinguish between human blood and blood from different provenance, such as animals at a species level.

Recent developments in the project include the ability to lift fingermarks from scenes of crime whilst retaining the integrity of the friction ridge pattern, and developing an *in situ* enzymatic digestion of blood marks so that multiple blood-specific proteins can be mapped. MALDI-MS can be used in imaging mode to map locations of target molecules which can produce identifiable images of the marks.




*© Sheffield Hallam University*
*MALDI-MS Imaging of in situ enzymatic digestion of a blood fingermark. The figure shows molecular images of blood specific peptides generated by three different concentrations of the enzyme (100, 150 and 200 g/mL, top-left, bottom-left and bottom right respectively) on the blood. A fourth concentration of 250 g/mL (top right gap) could not be delivered to due limitations in the spraying equipment. However, the figure suggests that the best ridge reconstruction performance could be achieved using an enzyme concentration of/between 150 and 200 g/mL.*

MALDI-MS would prove (if casework requires that it be known) that what has been visualised is truly human blood. The technique has been proven to work on older material and should be considered for use on cold cases. In addition, MALDI-MS is very sensitive and it may be possible to detect blood molecules where there are gaps in chemically-visualised partial marks to make them identifiable.

This process appears in Chapter 6 of the FVM as MALDI-MSI (page 6.2.10). The positioning of MALDI-MSI in the FVM as a low-maturity category C process will be reviewed during the production of the second edition to take account of the extra information and value it could add to criminal investigations, not only with the identification of blood, but including other target molecules such as drug metabolites.

# RESEARCH & DEVELOPMENT

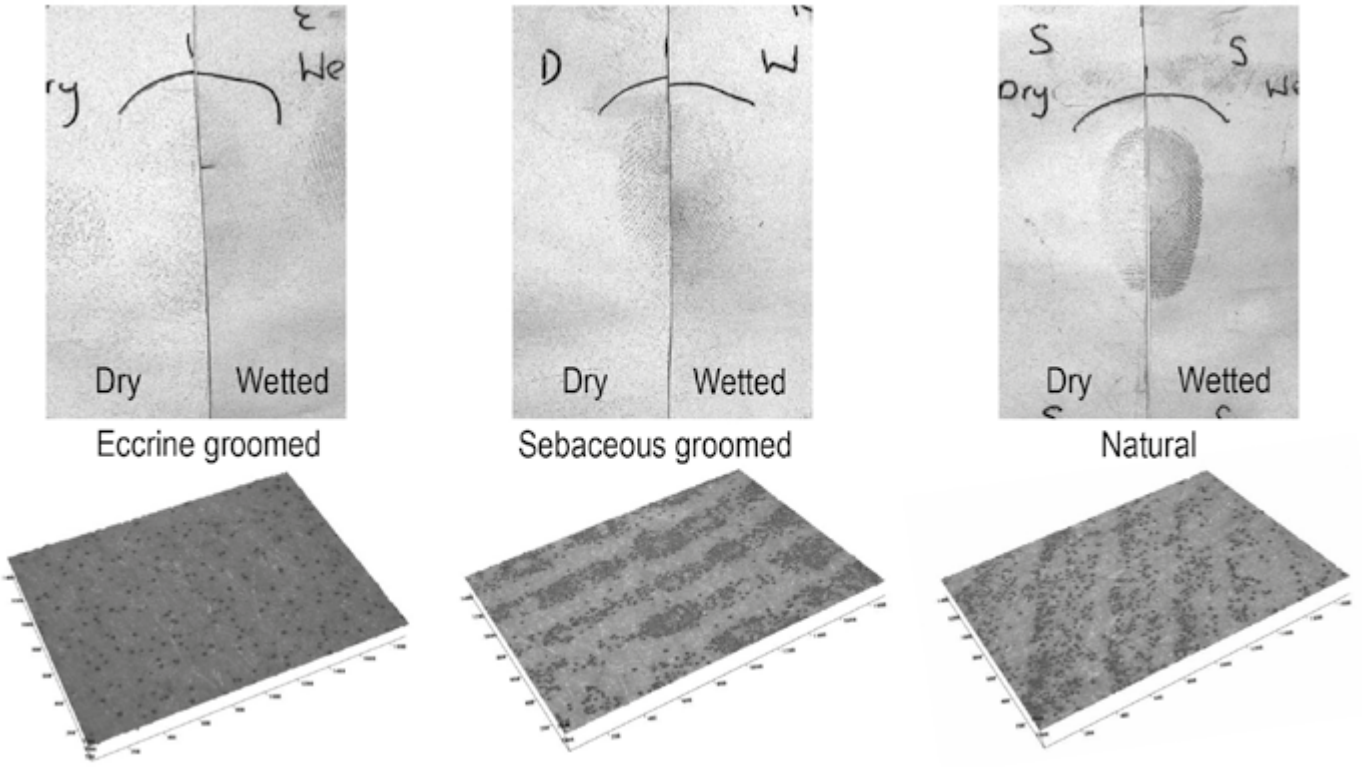
## Liquid metal deposition – Physical Developer - Update

CAST is match-funding a PhD study at Leicester University looking at the nucleation and growth phenomena of metal-based latent fingerprint technologies. Evidence from spot tests of chemicals and groomed and natural fingermarks indicate that both eccrine and sebaceous material must be present for most detailed Physical Developer development.

Microscopic analysis of fingermarks developed with Physical Developer show that for heavier marks with more material, silver particles are more frequent and smaller in size, giving rise to visualised marks of darker appearance with the opposite being true for marks with less material.

A novel approach of neutron reflectivity is being used to test the silver micelle theory, which is part of one of the proposed mechanisms for Physical Developer. Neutron reflectivity is able to probe if there are layers of detergent on a silver surface without being destructive to either the detergents or the surface.

Being able to determine the mechanism of action would enable a scientific approach to improving and modifying the process in the future.





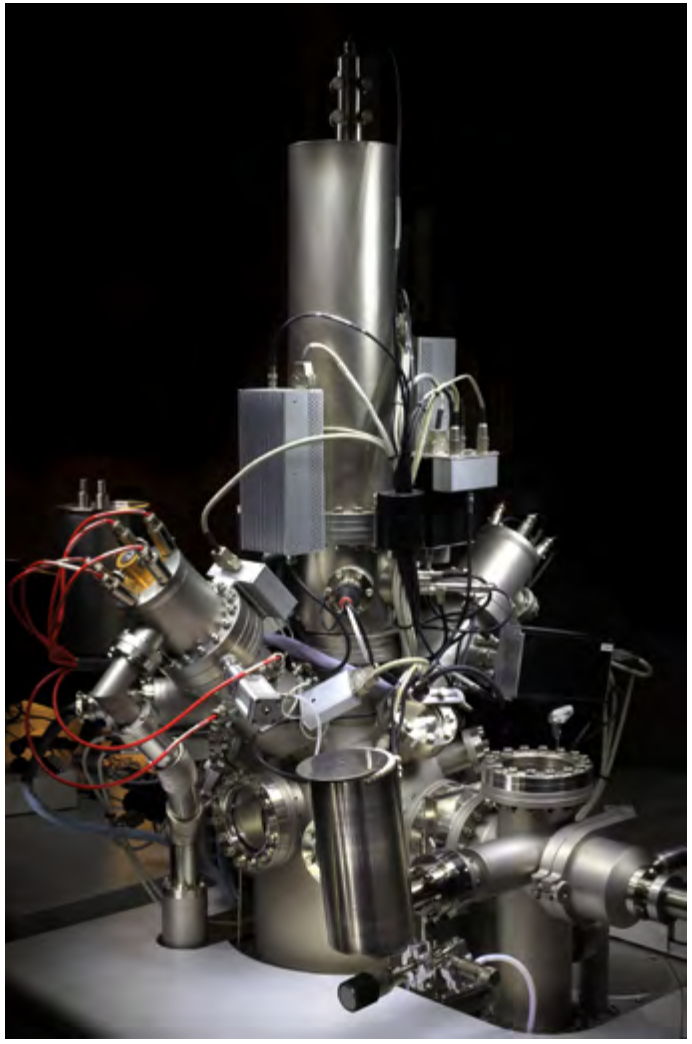

*Examples of eccrine and sebaceous groomed marks and a natural mark where the right halves had been wetted prior to treatment with PD and microscopic images of the dry half (wetted halves showed the same information).*

# RESEARCH & DEVELOPMENT

## Analysis of fingerprint residues on metal surfaces

CAST part-funded a summer student at Nottingham University to evaluate the applicability of several analytical techniques combining elemental/compositional detection with an imaging capability for the detection of eccrine and sebaceous fingermarks on brass and copper surfaces.

The techniques that were used included photoemission electron microscopy (PEEM), Raman spectroscopy, time-of-flight secondary ion mass spectrometry (ToF SIMS) and X-ray photoelectron spectroscopy (XPS). Fingermarks were deposited on brass and copper discs and then heated at range of temperatures up to 800°C before being analysed using all the above techniques. Similar analyses were also conducted on fired brass cartridge cases of varying calibres. The study primarily focused on eccrine fingermarks.



*© Interface and Surface Analysis Centre, University of Nottingham*

*Time of Flight Secondary Ion Mass Spectrometry (ToF SIMS) equipment*

Of the processes evaluated, ToF SIMS was found to be most effective in producing a clear image of the fingermark ridges, although ridges were only resolved on unheated samples (discs and casings) and had disappeared once the samples had been exposed to elevated temperature (or fired). Although some of the other techniques did identify features of interest, it was not possible to conclusively ascribe these to the presence of eccrine fingermarks, or to identify clear trends for what happens to fingermark residues during heating. The techniques all provided potentially interesting information about what is occurring in different surface regions of a cartridge upon firing, with changes associated with oxidation and deposition of carbon-rich material being observed close to the mouth of the casing.

The study has provided useful information on which techniques would be of most use in any future work in this area, and some of the techniques may give better results if ‘natural’ or sebaceous marks are used instead of eccrine. Additional future experiments are also planned.

CAST has regular communications with staff from operational laboratories about the implementation of processes and the perceived requirements of the ISO 17025 standard or Forensic Science Regulator (FSR) Codes of Practice and Conduct (and appendices). It is hoped that the following articles, which have been written from the perspective of the science underpinning the field of fingermark visualisation, will aid understanding of the requirement and steer decision-making and validation studies.

## Are we finding all the marks?

**No.** There are several reasons why this might be the case – some we can control, although others we have no control over. These are discussed below.

### (1) The complexity of mark visualisation and current capabilities

The aim of the practitioner is to visualise a mark with enough contrast between it and the surface on which it is deposited to proceed to the comparison stage. However, visualising fingermarks is complex due to the vast array of variables associated with the constituents of the mark (composition due to variations in sweat and in what is garnered from everything the individual has touched, quantity etc.), the substrate (type, condition etc.) and the surrounding environment (heat, rain, protected etc.). To complicate things further, all three factors change to varying degrees with the passage of time. Thus, from the perspective of visualisation (rather than identification), **a fingermark is a unique, complex, uneven and changing emulsion of chemicals**. [Note: this also infers that there is no 'standard' fingermark and care must be taken when interpreting findings from studies using such marks.] In practice this means that it is currently not possible to visualise all marks with one 'universal' process and multiple processes will be needed to increase the number of marks detected.

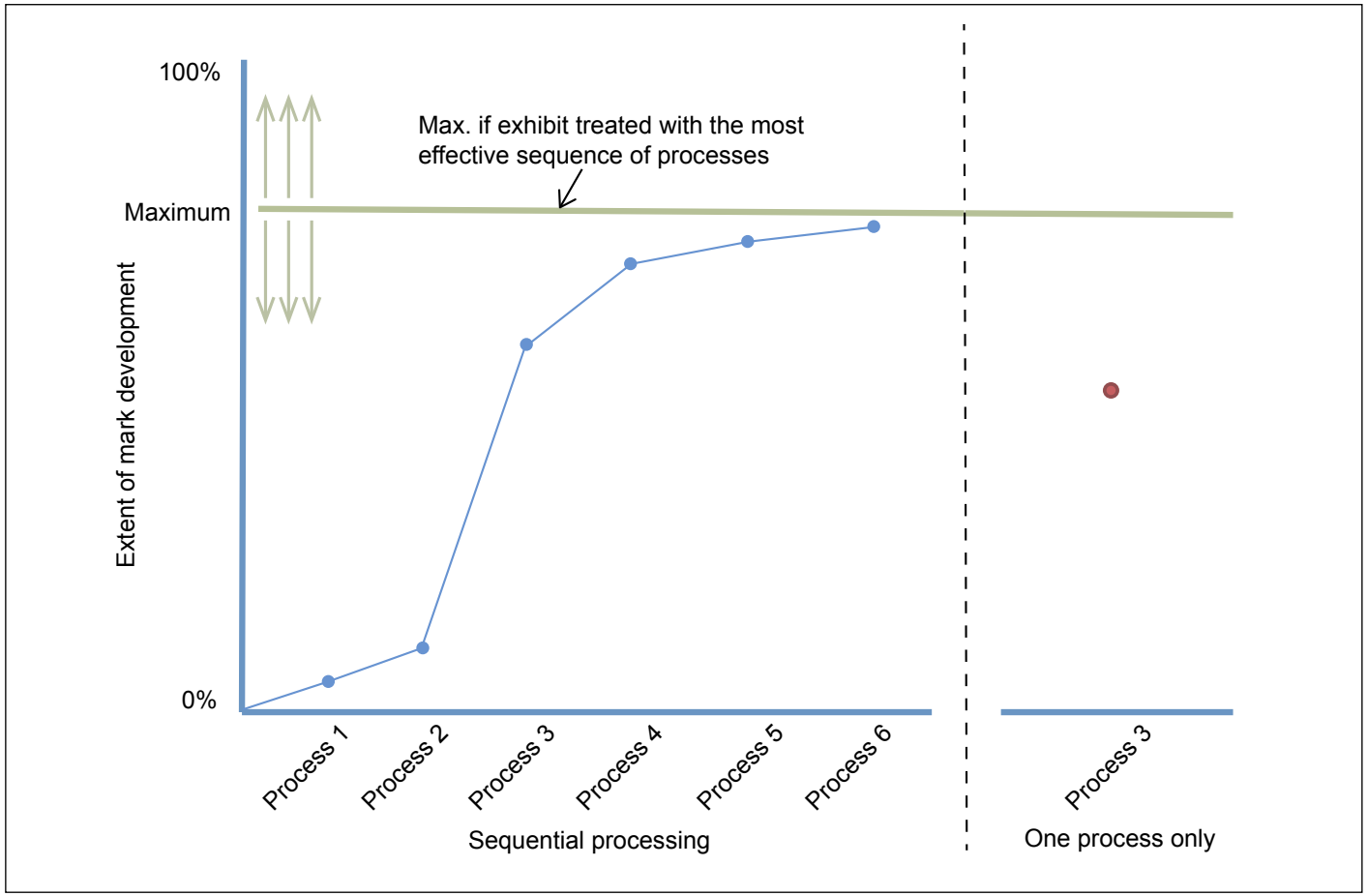
There are hundreds of visualisation processes in the literature claiming to be effective at finding marks. For well over 40 years, CAST (and its predecessors) has had an active research and development team who has, within reasonable expectations, made sense of the myriad of options by providing guidance to operational laboratories on how to maximise mark recovery through effective decision-making and implementation of processes. This has also included developing new methods where gaps in capability exist. The FVM is the latest guidance document and contains a broad range of processes.To put the scale of the options available into perspective, **there are close to 100 documented processes in the FVM that are capable of visualising marks** (this includes all processes in Chapters 5 and 6 and the various options associated with some processes, e.g. choice of powders etc.).

With this in mind, it is not unreasonable to expect that **the science behind some of the processes is not fully understood, but enough is known to ensure that most of them can be implemented in an effective and consistent way.**

**Some marks will not be detected due to limitations in current science and technology capabilities.** In the schematic on the next page this is represented by the area above the green line. Current processes are either not sensitive enough and/or are not utilising properties within the mark (e.g. their chemical or optical properties etc.). Research and development activities strive to keep this green line as high as possible, and that has been a fundamental goal of CAST over the decades. **It is extremely difficult to gauge how many marks are missed via this route as the vast amount of variables touched on above dictate this to a large extent.**

*"absence of evidence is not evidence of absence"*

FVM, Preface, page vii.




*Schematic showing the extent of mark development for a typical sequence of processes (left) and a single process (right). The green line indicates the maximum amount of marks that it is possible to develop with current capabilities. This bar may be raised as new processes are developed. Equally, it can drop as established processes become obsolete due to problems such as availability of chemicals. In the left schematic, processes 1 and 2 aren't particularly effective. Process 3 adds considerably to the extent of mark development. After that it is diminishing returns with each additional process. All of these processes have the capability to find unique marks i.e. those that other processes will not find. In the right schematic we're as close to the green line as we can get with one process.*

## (2) Decision-making

Throughout the whole process from crime scene to court, decisions have to be made that could impact on the extent of fingerprint evidence in a case. Focusing only on the visualisation part of this chain, **deciding what process, or sequence of processes, to use is key to maximising mark recovery.**

In basic terms, the more processes you use, the more marks you will find and processes must be used in a specific order.

This is illustrated in the schematic opposite where the extent of mark development gets closer to the maximum level (green line) with each additional process. It should be recognised that this is the ultimate performance and it is not always achievable for many reasons including constraints imposed by the investigation, resource limitations, local force policy etc. Thus **some marks will consciously not be detected due to operational decision-making.** An obvious example of this is the decision to treat volume crime exhibits with one process only. The impact of this is clearly shown in the schematic.

Getting close to the ultimate performance will also depend upon well-informed decision-making for process selection – this could be in relation to the exhibit, but also the staffs' level of understanding of the processes. **A poor decision due to lack of knowledge could result in a significant percentage of marks being missed.** An extreme example is choosing Superglue Fuming instead of Powder Suspension for treating a

smooth, non-porous surface that has been previously wetted. A less obvious example is choosing Superglue Fuming instead of Powder Suspension for treating a smooth, non-porous surface recovered from a crime that occurred a year ago. Again, it is hard to put figures on the impact of these decisions as there are so many permutations that any single figure would be meaningless as they would only relate to that specific study.

## (3) Implementation of processes

Across the UK, the standard of fingermark visualisation processing within laboratories is, generally, very high. For example, all laboratories use specially-designed chambers for two of the main processes: Ninhydrin and Superglue Fuming. However, it is possible to develop Ninhydrin marks with a steam iron or trouser press instead of an expensive oven. Likewise, it is possible to develop marks with Superglue Fuming using home-made kits that utilised equipment such as a fish tank and coffee heater. All of these approaches are successfully finding marks, demonstrating that **simply stating a process 'works' is not particularly informative.**

Almost all fingermark visualisation processes, relative to analytical techniques used in forensic science, are crude – often being described as 'bucket chemistry'. High tolerances exist in most processes, but it is still important to provide process instructions in the FVM that will give consistency and optimal mark development (to give the best chance of getting close to the green line in the schematic on page 14). Clearly some instructions will have more of an impact on mark development than others and it is important to distinguish between them.

The term 'critical parameters' may have given the illusion of a process 'working' if inside the tolerances, or 'not working' if outside. It should be apparent by now that this is rarely the case and a competent practitioner would be expected to know this. It may be that the language used in the FVM is too restrictive and CAST can revise if this is deemed the case. In any case, it is expected that practitioners will strive to meet the requirement for optimal performance as set out in the FVM for process implementation unless they have evidence to suggest otherwise.

Following on from this, **a key difference between fingermark visualisation processes and other analytical forensic science techniques is that there are no minimum standards for fingermark visualisation processes and the high point for optimal development is constantly moving.** For example, light sources for use in fluorescence examinations are constantly improving, resulting in more mark detection. This does not mean that a reasonably modern light source used by a police force is no longer effective as soon as an improved product comes to market. This can make processes difficult to assess by auditors where minimum standards are typically easier to measure against.

## (4) Staff competency

There is one fundamental requirement for all of the areas discussed so far – **the staff must be competent to do their job role.** For decision-making on how best to recover marks from complex exhibits or areas, a practitioner should be familiar with the bulk of the content in the FVM. Whilst a practitioner using the process should, as a minimum, be able to follow their standard operating procedure but also have a deep enough understanding of the process to be able to recognise when it is not working correctly and act on it.

There are a couple of other factors that are not often discussed and generally not considered. These are the ability of staff to see and recognise fingermarks. Not being able to do either will have as much impact on the result as variations in any visualisation process parameters.

## Validation studies

The CAST protocol for process validation has been described in detail in a scientific paper published in 2012.[1] The paper was written in response to inconsistent and often poor methodologies used in fingermark visualisation studies in the literature. The key stages for getting a process from an initial concept through to something than can be used in an operational setting are described. This is also summarised in Appendix 2 of the FVM.

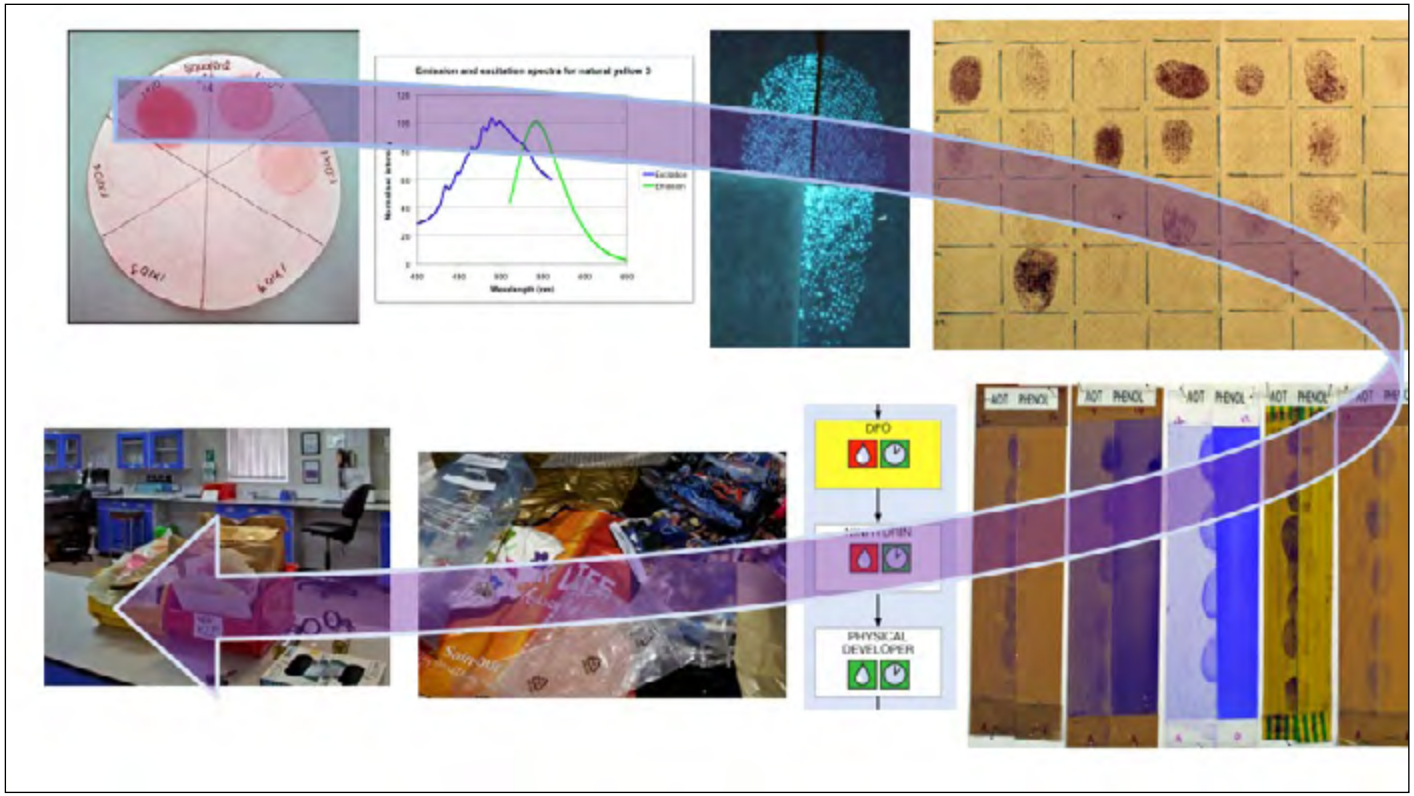
Following on from this publication, the International Fingerprint Research Group (IFRG) felt that the topic was so important that they published a paper, written by the IFRG members, which

1 Sears, V. G., Bleay, S. M., Bandey, H. L., Bowman, V. J. (2012) A methodology for finger mark research, Science Justice, vol. 52(3), pp 145–160.

expands on and extends the detail within the CAST paper.[2] The lead forensic journals now expect this scalable and adaptable methodology used in both papers to be followed and significant deviation justified. **It is expected that any validation studies would follow this internationally-accepted methodology.**

2 International Fingerprint Research Group (IFRG) (2014) Guidelines for the Assessment of Fingermark Detection Techniques, Journal of Forensic Identification, vol. 64 (2), pp 174–200.

A full validation study of a new process, depending upon its intended use and position in a sequence, can take many years to complete due to the complexities of fingermarks. As an example, CAST has so far carried out in excess of ten man-years of investigation in the use of Indandione as a replacement for DFO. This study included optimisation (both of the formulation and the development conditions), extensive laboratory trials and a pseudo-operational trial.




*Typical steps used during a full validation study*

We are exploring the possibility of conducting the final stage of a full validation via an operational trial. This study has met the standard methodology protocols as outlined above. Not all studies take this long, but very few can be completed without at least several months of effort by dedicated and experienced staff to investigate the impact of the many variables thoroughly – and this is for one process.

CAST has investigated applying statistical models to such studies, including engaging with statisticians from academia. However, a meaningful solution has proved difficult to achieve – even for such large studies such as the one mentioned above.

In order to gain any statistical information, the many variables have to be controlled, and the more they are controlled the further we get from real marks – and ultimately these processes must be effective at visualising real marks. It may be that there are better ways of getting insight into the statistical significance of such studies, but for now we must accept that a meaningful solution has not been found. The CAST methodology paper states, “The difficulty and complexity in applying statistical models to analyse the results from finger mark experiments should not be underestimated”. Whilst the IFRG methodology paper states, “Advice from a statistician may be required in terms of determining an acceptable number of repeats and how the data should be treated and interpreted”.

In summary, a full validation clearly requires a significant body of investigation to ensure a process is fit for purpose. It is unrealistic to expect a UK fingerprint enhancement laboratory, without dedicated research staff, to conduct such work without negatively impacting on the operational work. Fewer tests will clearly be required to demonstrate that a previously validated process 'works in their hands'.

An operational laboratory should not be re-proving the science – this is unnecessary and difficult to do without specialist facilities and experienced staff dedicated to validation, especially in a laboratory whose main focus is operational work. However, tests should include essential elements of the methodology (such as use of a range of donors, representative substrates, ages of mark etc.) to demonstrate that the process works as expected on the types of exhibit typically handled by that laboratory. They should not include factors such as varying the operating parameters in a Superglue Fuming cabinet or Ninhydrin oven for example.

## Fingerprint Source Book – update

Editor: Dr Stephen Bleay (**stephen.bleay@homeoffice.gsi.gov.uk**)

As part of the activity to obtain accreditation to ISO 17025 in 2012, CAST produced a Fingerprint Source Book containing details of all the processes recommended in the Manual of Fingerprint Development Techniques, and of many other processes that had been evaluated by CAST in 40+ years of research. This included details of the scientific theory behind each process and the validation work conducted by CAST, and 'validation libraries' of supporting literature were compiled for each of the principal processes within CAST's original scope of ISO 17025 accreditation.

This Source Book was subsequently made publically available and can be accessed on GOV.UK:

**https://www.gov.uk/government/publications/fingerprint-source-book**

Following the publication of the FVM in 2014, CAST has been working to update the Source Book, revising language to make it consistent with the FVM, correcting errata, and including relevant literature published since 2012. The revised Source Book sections have been externally peer reviewed by experts in the international fingerprint research community, and it is the intention to complete the revision of the Source Book and make version 2.0 widely available via GOV.UK by the end of April 2017.

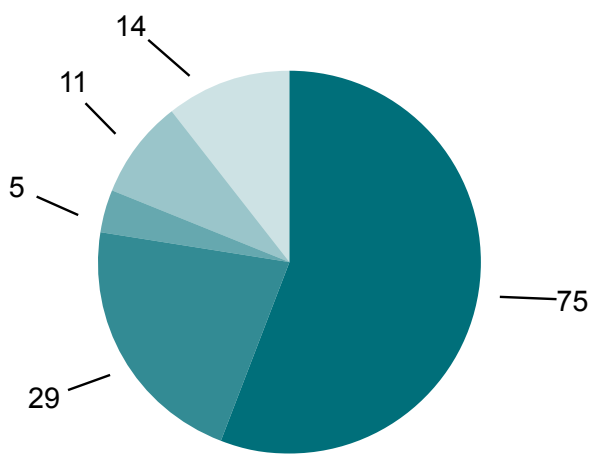
The Forensic Science Regulator's Codes of Practice places emphasis on practitioners being familiar with the body of research that underpins the processes that they are using. The Source Book provides a good starting point for any practitioner to understand the theory behind the process, the reasons for the formulations and processing conditions recommended by CAST, and the level of validation conducted by CAST prior to operational implementation. It is hoped that the revised Source Book will continue to prove a valuable resource in this respect.

# ADVICE SERVICE

During the first six months of financial year 2016 to 2017, CAST answered 134 fingerprint forensic enquiries, including ISO 17025 for this area. This represents an increase of just less than 25% over the first six months of last financial year. These were mainly in the form of telephone calls and emails.

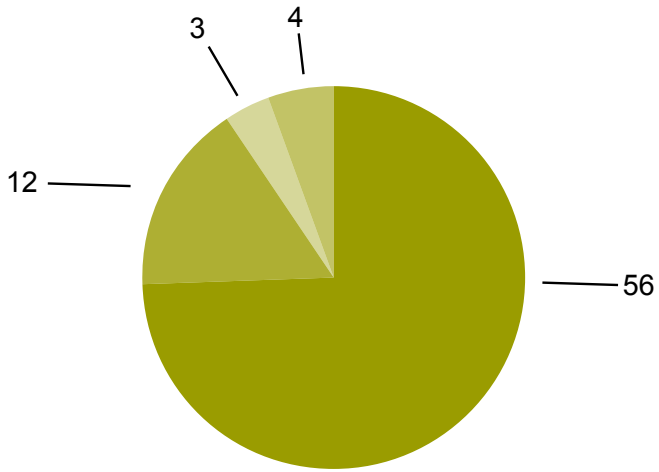
If you use this service it is important that you give feedback on the usefulness of any the advice given, especially if it has a positive outcome as this will help CAST monitor the impact of the service given and help with its future provision.

## Who (134)



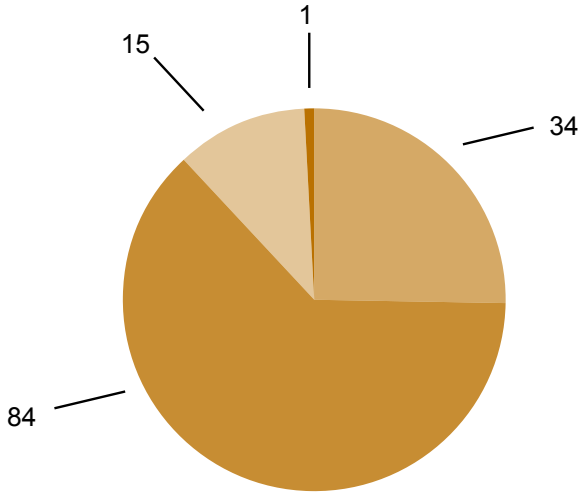

- 75 from UK law enforcement agencies
- 29 from international law enforcement agencies and academic institutions
- 5 from commercial organisations
- 11 from UK academic institutions
- 14 others including Home Office and other government departments.

## Subjects Headings by UK LEAs (75)




- 56 about Fingermarks and Forensic issues
- 12 about ISO 17025 and quality issues
- 3 about Footwear
- 4 about Other (Inc H&S, Lab design issues, DNA, Crime Scene etc.)

## Time taken to provide an answer (134)




- 34 less than 15 minutes
- 84 between 15 minutes and 1 hour
- 15 between 1 and 4 hours
- 1 between 4 hours and 2 days

# ADVICE SERVICE

## Guiding industry to develop fit-for-purpose equipment

In July 2016, CAST was able to have a Ninhydrin chamber (NINCha) from Attestor Forensics and their distributor ForenteQ Ltd to study for a few days. It was originally designed (at the request of an international organisation) to heat and humidify Ninhydrin-treated samples at 30°C and 65% relative humidity (RH) for 24 to 48 hours and sometimes longer. These processing conditions are unlikely to be acceptable for the workflow in UK laboratories. Thus we worked with the technical director and found out that it could be run at the settings in the FVM (80°C; 62% RH) with some modifications to the hardware and software. We carried out only a basic study in the short timeframe, so if police forces wanted to purchase one of these chambers they would have to do their own validation of the system, but initial tests were promising.

*Loading the Ninhydrin cabinet for testing*

## CAST collaborating with Foster + Freeman Ltd on novel powder suspensions

In November 2016, CAST collaborated with Dr Roberto King from Foster + Freeman Ltd to explore novel fluorescent powder suspension formulations. CAST's understanding of detergent solutions for powder suspensions, and Dr King's knowledge of fluorescent materials combined with some of the latest Foster + Freeman technology has led to some promising early results. These feasibility studies have progressed into 2017, and it is anticipated that a technical note of the findings will be submitted to a journal for peer review in the next few months.

## Greenhouse gas reduction

Last year CAST reported on 'Regulation (EU) 517/2014 on fluorinated greenhouse gases' and how it might impact the future use of fluorinated solvents such as 3M NovecTM HFE7100 used in DFO, Ninhydrin and Indandione.

Since that time, the parties to the Montreal Protocol on Substances that Deplete the Ozone Layer (nearly 200 countries) reached agreement on 15 October 2016 in Kigali, Rwanda to phase-down hydrofluorocarbons (HFCs). HFCs are commonly used alternatives to ozone depleting substances. Whilst not ozone depleting substances themselves, HFCs are greenhouse gases which can have high or very high global warming potentials.

It was agreed in the phase-down schedule that developed countries would start to phase-down HFCs by 2019. By the late 2040s, all countries are expected to consume no more than 15 to 20% of their respective baselines.

The United Nations Environment Programme website has further details. The following news article gives a summary of the Kigali meeting:

**http://web.unep.org/africa/news/kigali-amendment-montreal-protocol-another-global-commitment-stop-climate-change**

The UNEP also produce a fact sheet for the HFC phase-down:

**http://multimedia.3m.com/mws/media/1365924O/unep-fact-sheet-kigali-amendment-to-mp.pdf**

The Environmental Investigation Agency website also has information and the following document gives a summary of the phase-down schedule:

**https://eia-international.org/wp-content/uploads/EIA-Kigali-Amendment-to-the-Montreal-Protocol-FINAL.pdf**

CAST will continue to monitor the situation and act accordingly.

## The National Scientific Support Laboratory Conference

On the 15th November, Greater Manchester Police, on behalf of the FEL Expert Network group, organised and hosted an excellent National Scientific Support Laboratory Conference. The event was the first of its kind for many years and a valuable opportunity for laboratory practitioners to network with colleagues and suppliers, share experiences and ideas, and listen to a full day of wide-ranging talks.

Presentation topics including fingermark visualisation on metal surfaces and the new £5 polymer banknotes; advancement in processes such as VMD and infrared fluorescence; operational experiences around laboratory and CSI collaboration and the journey toward the establishment of the EMSOU-FS; a range of talks relating to quality standards from different perspectives (police force, Forensic Science Regulator's office, CAST); and updates from College of Policing and the future of forensic training, and the Forensic Science Special Interest Group and the UK Innovation Database.

## The European Network of Forensic Science Institutes (ENFSI)

### MP2013: Proficiency tests and collaborative exercises for the fingerprint domain (Jan 2015 to June 2017) – update

CAST contact: Jonathan Vaughan (**jonathan.vaughan@homeoffice.gsi.gov.uk**)

The aim of the project is to examine how proficiency tests (PTs) and collaborative exercises (CEs) are organised across Europe and explore their role in raising standards within the fingerprint profession.

Whilst participation in PTs is a key element in the ISO/IEC accreditation process, it has also been found that participation in CEs is a useful mechanism for laboratories to monitor the quality of their analytical results. The major difference between the two is that, for CEs, the results of participants are shared to enable further discussion around knowledge and practice, whereas for PTs the findings are for the organisation's benefit only.

The project has found that the availability and use of PTs is at present very limited in the fingerprint domain. There are only a handful of providers and, from a practitioners' viewpoint, the perceived quality of some of these tests are not regarded as sufficient.

The ENFSI Fingerprint Working Group, as a result of the project, has now established a PT/CE Advisory Board which will work to agreed guidelines to engage with providers on behalf of its members.

The project has so far run one round of PTs and two rounds of CEs, the latest one provided at the annual ENFSI Fingerprint Working Group conference in Belfast in September 2016. The exercise is now closed and the team aim to publish the results in a peer-reviewed journal during 2017. An article has also been submitted that explores past experiences and future perspectives for these schemes and is currently awaiting publication.

# ‘Grease is the Word!’

CAST contact: Helen Bandey (**Helen.Bandey@homeoffice.gsi.gov.uk**)

As part of CAST’s role on the ENFSI Fingerprint Working Group steering committee, we are responsible for organising a half-day Fingermark Visualisation workshop at the annual conference that will promote good practice and cross-organisational learning across Europe.

The 2016 conference was hosted by the Police Service of Northern Ireland (PSNI) in Belfast during September and the visualisation workshop was held within the PSNI fingerprint laboratories. The event was well attended with more than 40 delegates from across Europe participating.

This year’s theme was ‘Grease (+other contaminants) is the word!’ PSNI laboratory staff prepared samples (white tiles with a range of greases and other contaminants from the kitchen, bathroom and garage – see table opposite) ahead of the conference.

Participants were given the opportunity to visualise marks with a range of processes at five different workstations including Fluorescence Examination (untreated, Natural Yellow 3, and Superglue Fuming followed by Basic Yellow 40), Powders, VMD (silver), lipid stains (Solvent Black 3) and Powder Suspension (iron- and carbon-based). Some also took the opportunity to try sequential processing routes.

| Kitchen | Bathroom | Garage |
|---|---|---|
| Margarine | Cough Syrup | Used Compressor Oil |
| Butter | Sun Cream | Used Engine Oil |
| Lard | Shampoo | Diesel |
| Ketchup | Conditioner | Unleaded Petrol |
| Light Mayo | Shower Gel | 2-Stroke Oil |
| Diet Coke | Hair Gel | Coolant |
| Coffee | VO5 Hair Putty | Brake Fluid |
| Tea | Face Wash | Used Fuel/Oil Mix |
| Milk | Baby Oil | Synthetic Engine Oil |
| Beer | Cocoa Butter | Grease |
| White wine | Body Lotion | Lithium Grease |
| Olive Oil | Hand Cream | WD40 |
| Sunflower Oil | Foundation | Plant Food |

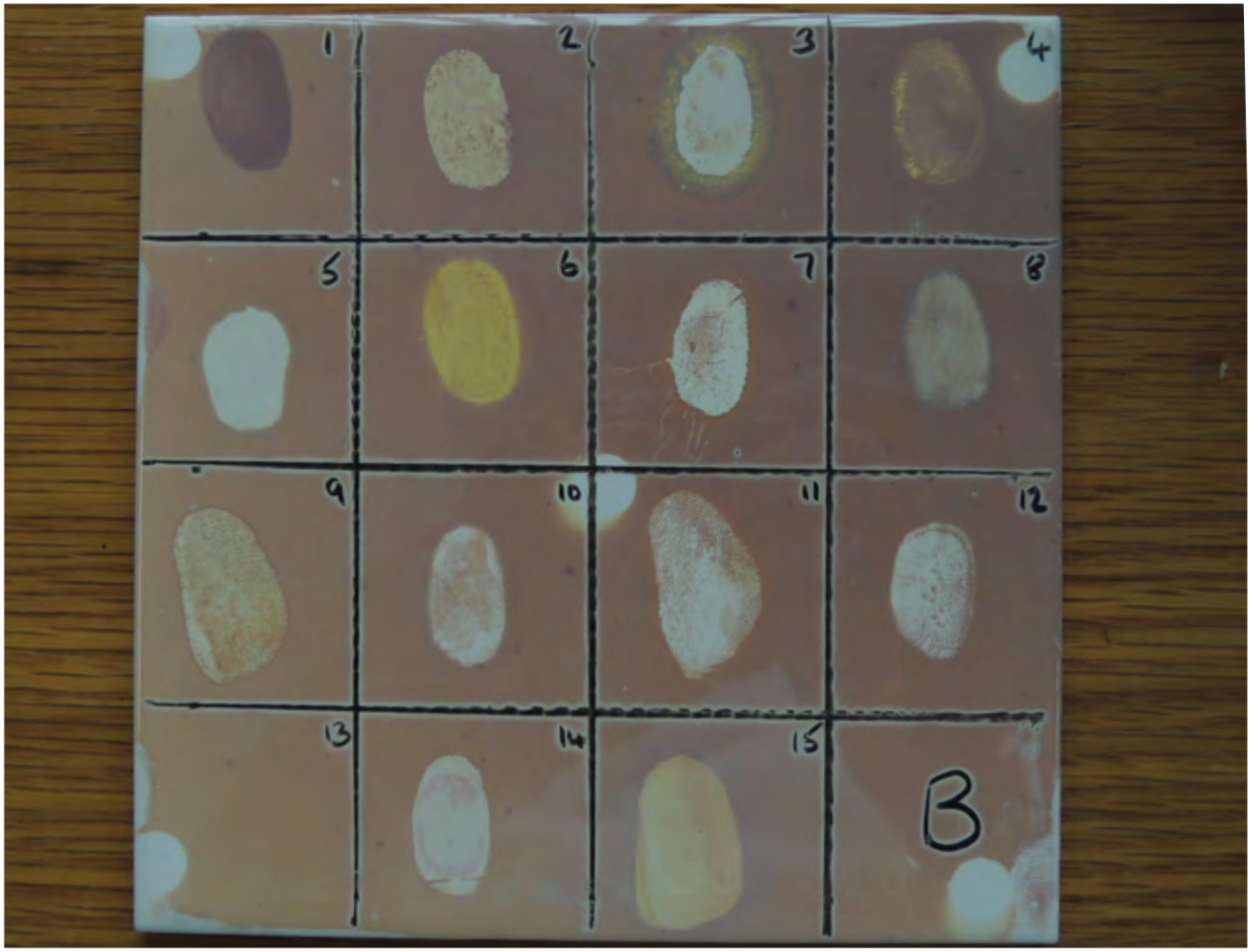
*Greases and other contaminants in which fingermarks were deposited and developed during the visualisation workshop at the 2016 annual meeting in Belfast*

Although not a scientific trial, approximately 1,500 marks were visualised and some interesting observations were noted which, if thoroughly tested and validated, may lead to changes within the non-porous, grease charts in the FVM (Chart 1B, page 4.23). They include:

1. Powders, often dropped from recovery plans when marks in grease are the focus, were more effective than expected by participants (probably due to the fact that the contaminant-rich marks were deposited onto a clean substrate).
2. Any marks not visualised with Powders were subsequently visualised with Powder Suspension – this is in agreement with many of the non-porous charts where the processes are complementary.
3. VMD (silver) was extremely effective across most contaminants whether grease-based or otherwise; the silver coating typically deposited on the background in preference to the mark.
4. Solvent Black 3, as expected, visualised grease-based marks well but was not as effective as other processes on non-grease-based contaminants.
5. Solvent Black 3, when used after VMD (silver), stained the silver coating across the surface in addition to the grease-based contaminants thus making this sequential route ineffective.

Feedback from participants was particularly positive with comments such as, “One of the best visualisation workshops ever!”, “Good subjects for visualisation workshop – I will need it for my work” and “It was very interesting and excellent work with a high level of technical content.

# OTHER NEWS




*Images from the ENFSI visualisation workshop at the PSNI laboratory*

## Science Museum Late

On 30th November 2016, CAST exhibited in Kensington, London as part of the Science Museum Late event entitled ‘A Night of Crime’, in support of the Jill Dando Institute from University College London. Nearly 4,000 members of the public were given the opportunity to learn about a range of CAST’s business areas, and see science in action with demonstrations, workshops and talks focused on:

- drones;
- searching for evidence: ground penetrating radar and side scanning sonar;
- the analysis of drugs and new psychoactive substances;
- stand-off detection of concealed weapons with millimetre-wave imaging;
- 3D printing – threats and opportunities
- the ‘dark web’ and Bitcoin;
- fingermark visualisation approaches, and the FVM.

Laura Hussey, Amelia Thomas-Wilson, Rory Downham and Stephen Bleay represented CAST’s fingermark visualisation business area. Features included a display screen with rolling images of modern visualisation processes in action; a look through pages of the FVM advice publication; a fluorescence examination demonstration station; a spotlight on the new £5 banknotes and the challenge they have posed; and hands-on activities involving the imaging of marks with oblique lighting and the use of gelatine lifters.

*Laura Hussey demonstrating visualisation processes at the Science Museum Late event on the topic of ‘A Night of Crime’*

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## Publications

For comments on this newsletter, please contact **Helen.Bandey@homeoffice.gsi.gov.uk** (editor).

This newsletter and other CAST fingermark visualisation publications can be found on the following website:

**https://www.gov.uk/government/collections/centre-for-applied-science-and-technology-information#fingermark-documents**

For sales of the Fingermark Visualisation Manual please contact Clare Polley, Official/Libraries Sales Manager, TSO (**clare.polley@tso.co.uk**)