Review of Research and Development in Forensic Science:

Other responses

Contents-Other responses

Organisation Name	Response Type
ACPO	Substantive
Advisory Council on the Misuse of Drugs	Substantive
Analytical Services International Ltd	Response on behalf of Analytical Services International Ltd both as an academic researcher and a forensic service provider
Association of Forensic Service Providers' Body Fluid Forum	Substantive
CCL Forensics	Substantive
Cellmark Forensic Services	Substantive
Crown Prosecution Service	Substantive
DSTL	Substantive
Faculty of Forensic and Legal Medicine	Substantive
Forensic Access Ltd.	Substantive
Forensic Isotope Ratio Mass Spetrometry (FIRMS) Network	Substantive
Forensic Science Northern Ireland	Substantive
Forensic Science Service 1	Substantive
Forensic Science Service 2	Substantive
Forensic Science Society	Substantive
Forensic Telecommunication Services Ltd	Substantive
Forensic Working Group for the Partnership against Wildlife Crime	Substantive
Freelance Scientists (but aligned to universities)	Substantive
Home Office Scientific Development Branch (name changed to Centre for Applied Science and Technology in April 2011)	Substantive
Intellect (trade association for the IT, telecoms and electronics industries)	Substantive
LGC Forensics	Substantive
LTG Executive Committee	Substantive
The Macaulay Institute, Aberdeen	Substantive
National DNA Database Ethics Group	Substantive
National Physical Laboratory	Substantive
National Policing Improvement Agency	Substantive
Natural History Museum	Substantive
Prospect	Substantive
RAND	Substantive
RCUK	Single substantive response submitted on behalf of the Research Councils
Royal Statistical Society	Substantive
Wellcome Trust	Response to question 1 only: re: reseach funding
West Midlands Toxicology Laboratory	Substantive

ACPO

ACPO response to the Home Office Review of Forensic Science R&D

1. Introduction

1.1 The Association of Chief Police Officers (ACPO) is an independent, professionally-led strategic body. It leads and co-ordinates the direction and development of the police service in England, Wales and Northern Ireland, working in partnership with Government and the Association of Police Authorities. ACPO is an association of chief officers bringing together their experience and expertise to help the police service deliver effective policing on behalf of the public. It does this through the work of its 'Business Areas', each of which is responsible for setting overall direction and developing national strategy and policy for specific policing functions or particular areas of business.

1.2 ACPO is supported in carrying out its strategic role by the National Policing Improvement Agency (NPIA). NPIA was established in 2007 with a remit to improve public safety by building capability across the police service, providing professional expertise to police forces and authorities and providing critical national services. NPIA works in partnership with ACPO and its business areas and can be commissioned to deliver programmes and projects to improve capability and support front line delivery. NPIA has worked with ACPO in developing this response to the review of research and development in forensic science and the response incorporates work that NPIA has developed and delivered on behalf of the police service.

1.3 The current situation regarding research and development in forensic science presents a fragmented and unclear picture that provides many challenges in the current fiscal environment. The are significant risks to the reputation of the Government and Criminal Justice System that has been highlighted by recent high profile cases where the efficacy of forensic science has been challenged, examples being the Omagh bombing and Mckie case in Scotland where the ramifications are still not fully known.

1.4 This clearly demonstrates that challenges exist and will continue to explore the gaps in the CJS to exploit scientific methodologies that should be assured and safe in the eyes of the courts and public. The requirement to harness emerging technologies and methods has never been more important in the search for the truth, but these need to be immune from challenge and risk free.

1.5 The requirements of the service as a whole should be focussed on several key elements that cover the needs of ACPO and the CJS as a whole. These can be summarised in the following points:

- **Public safety** – this is the overarching requirement to ensure we develop a society where the public feel safe and the Criminal Justice process is able to protect them from harm. Science can make a significant contribution to this strategic aim
- **Crime reduction** – this impacts upon society as a whole in using science to reduce actual crime, but also reducing the fear of crime whilst increasing the opportunities for detection of offenders
- **Value for money** – in the current fiscal environment, there is a responsibility on the public sector to ensure that activity is proportional, accountable and delivers value for money
- **Reputational risks** – this applies to the Government, policing and the criminal justice system as a whole in that we need to ensure that the forensic science used in the CJS is assured and reliable and not exposing risks to those applying it
- **Public confidence** – the public should have confidence in the reliability of forensic science and those presenting in the CJS. Any confidence gaps in science will be exploited to the full by the defence, therefore we need to ensure that these gaps are filled with reliable scientific methods
- **Fair and equitable delivery of justice** – the latest scientific developments should be available to the courts to determine the facts, it is equally important to eliminate, as well as implicate using scientific methods
- **National consistency** – we should ensure that the standards used for the delivery of scientific evidence is consistent across the country and the Forensic Regulator has a key role in ensuring the application of a consistent approach

1.6 Within this document, ACPO will explore the challenges, the current position demonstrating areas of good practice and also the weaknesses, as well as a vision for the future landscape that will provide the police service with assured scientific methodology that meets the requirements of the criminal justice system.

2. ACPO Priorities

2.1 The NPIA has worked closely with ACPO to develop a co-ordinated approach for the use of science and technology resulting in the publication of a strategy document detailing the overall policing requirements. The Police Science and Innovation Strategy seeks to maximise the finite resources available for research and development across all scientific disciplines, including Forensic Science and ensure that funding is directed to where it will have the biggest impact in meeting the key challenges facing the service.

2.2 The strategy aims to deliver improved police capabilities year on year; ensure that policing decisions are supported by robust knowledge about the impact and effectiveness of different approaches; and harness radical long term scientific developments. The delivery of these goals is based on the 3 key principles for action.

- **Coordination** – where there are clear priorities for police science and innovation and where the different activities of the organisations involved align together to have maximum impact;
- **Collaboration** – where research and development work engages police officers and the public; and where specialists from different sectors and disciplines work together – encouraging innovation to transfer from one area to another;
- **Challenge** – where investment in innovation is targeted to where it will deliver the strongest benefits; where these are realised faster than in the past; and where we challenge others to help address the most pressing police needs of the future.

2.3 In 2010, ACPO commissioned the NPIA to establish a schedule of priority areas in how science and technology could be used to solve problems identified in policing. This was carried out through a consultation exercise with ACPO leads in business areas, forces and end users in order to determine a national context. The responses could be collated into five distinct themes and for the first time, provides an overall position of the problems in policing from the perspective of the service. These issues fall into the following priority thematic areas :

- Using knowledge, information and intelligence in policing
- Enhancing police investigations
- Tackle the criminal exploitation of technology
- Increase collaboration between forces
- Enhance the role of communities and partner agencies in policing

The consultation identified capability and knowledge gaps within all categories and there is an ongoing exercise to map activities being carried out by NPIA, HOSDB and policing against them in order to carry out a gap analysis.

2.4 ACPO recognises the value of developing a co-ordinated approach to the delivering solutions to policing through its portfolio structure, and has a specific sub group of the Forensic Science portfolio to address support and implementation of science and innovation. The chair of this group is ACC Mark Gilmore of West Yorkshire Police and the terms of reference (Appendix A) for the group focus on how science and innovation in forensic science can contribute to public safety. The basis for the work of the group is the science and innovation strategy and the priorities agreed by CC Council in October 2010 Appendix B).

2.5 ACPO will use the Forensic Science portfolio structure to ensure that the maximum benefits can be derived from forensic science within the fiscal and organisational constraints placed upon the police service. The current forensic landscape presents challenges to policing and the criminal justice system that are unprecedented, with the closure of the Forensic Science Service and funding allocation reductions across all public services being the most significant issues. The priority therefore, for ACPO, is that the police service as a whole embrace these

challenges as opportunities to maintain services in a more focussed manner, and direct the available research capability towards policing problems.

3. Risks and Issues

3.1 The review of forensic science research and development has come at an opportune moment in the current environment of austerity and rationalisation of services. The ability to respond in a co-ordinated manner to issues within the criminal justice system utilising science and innovation is critical to the prevention and detection of criminal activity. The role of the ACPO is to provide the strategic direction and utilise all available resources including the NPIA in particular to provide structure to the process. There are some areas of good working practice but there are some significant deficiencies in the current situation. The forensic R&D landscape very much lacks co-ordination across academia, industry, policing and indeed government itself.

3.2 The key issues that need to be surfaced from the review are that the use of science in the context of policing and the CJS is wider than only forensic science, it encompasses the societal aspects that tease out in many cases the underlying issues and the implications of scientific advances. There are many examples of this but the use of DNA presents a very good topical situation where the science in use is advancing rapidly making biological discrimination even more powerful, but this needs to be balanced against the requirements of the Freedom Bill in the retention of reference samples. There are also ethical implications and the public perception of how DNA could be used outside of its current remit. The Human Genome project can provide a far wider profile of the biological information available, but the issues that need to be considered go far beyond the actual science. ACPO will play a critical role in ensuring the use of science is focussed on the requirement and that development needs are proportional.

3.3 In terms of the current situation, the levels of funding in forensic research and development are very unclear. This is principally due to the fact that there is no central oversight of :

- How much funding is available in this area
- What the available funding is being spent on
- Who is actually spending the money
- How the funding is linked into government priorities
- What the outcomes of the research are
- What are the governance and accountability arrangements for the oversight of spend and performance delivery

What is clear is that there is a disconnect between the funding available through the research council network and academia, and the requirements of the criminal justice system. The CJS is not represented in the decision making process for funding and therefore not able to influence where the funding is directed. There is some, but little

evidence to suggest that the research funding available is taking account of policing requirements, but as an example, the Engineering and Physical Sciences Research Council (EPSRC) have a crime reduction theme for their programmes but in the 93 projects listed, with an overall funding level of £67m, there are only two policing partners listed across two different projects[1]. This clearly demonstrates a failing in the current system from the perspective of the CJS and perhaps there are opportunities to realign some of the available funding in this area towards projects that firstly directly support the strategy and secondly can be applied in an operational environment to support the principles indicated above.

3.3 In an attempt to resolve this situation, the ACPO are actively working with NPIA to rebalance this situation whilst attempting to influence the universities, however, engagement with the research councils is fairly limited. Within the NPIA structure there are limited resources available who are dedicated to developing the strategy on behalf of ACPO in order to drive investment into the priority areas, but this is a relatively new initiative that is starting to gain some momentum through the ACPO Forensic Science and Innovation Board. The issue here is that the closure of the NPIA and uncertainty of its functions will inevitably result in a void that will need to be filled through some alternative means if the police service requirement is to harness forensic science research and development. These co-ordination activities carried out by the NPIA with the strategic direction from ACPO enables the potential of forensic science to be improved, examples of this being the work on rapid DNA, ADAPT where the ACPO have identified a requirement and this has been developed by the NPIA under a project management structure.

3.4 The phasing out of the NPIA presents some challenges that require consideration. At the present moment, many forensic activities are within a central point, but it is clear from the emerging communications that the intention is to split these functions, training, policy, databases etc into different areas of governance. Once the final decisions have been made, there will be a requirement to ensure that there is still some co-ordination of strategic direction through the ACPO structures and governance arrangements and the ability to ensure that activity supports the science strategy. As part of this functionality, the maintenance of the strategy requirements to ensure they are current and the ongoing work to deliver the strategy should continue in some capacity. This capability has evolved over the past years and is now providing the meaningful link between requirements and outcomes and everything that sits between. There is a risk that the progress made to date will be lost unless consideration is given to a co-ordination function around this area. Another benefit of the current situation, is the ability to be able to align the implementation of research and development with learning programmes covering specialist forensic

[1] http://gow.epsrc.ac.uk/ChooseTTS.aspx?Mode=SOCIO&ItemId=9

training but also wider police training as part of the knowledge strategy under the strategic direction of CC Sara Thornton, ACPO lead in this area.

3.5 At the present moment, there is no central oversight of scientific activity or research that could be utilised across other government departments, and there are also opportunities to review the situation within the Home Office departments such as SOCA, NPIA, UKBA, IPS, HOSDB etc all who have an element of forensic science within their operating structures. Many of the forensic science techniques that are currently in use in policing have evolved from other applications. The origins of both DNA and fingerprints were not in policing, DNA came from the health environment and university network by Professor Alec Jeffreys in 1988, and the use of fingerprints dates back to the colonisation of India where the fingerprint was used as a personal identifier of soldiers. Both DNA and fingerprints have been around for some time but their application in a criminal context came later. There will be many examples of this throughout history but the clear message is that we should learn from these examples and ensure that scientific research may have more than its original considered application. The challenge is to carry out the horizon scanning and determine what can be utilised in the CJS.

3.6 Whilst the activities carried out by HOSDB are focussed around the Home Office departments, there is a high proportion of their activity in non forensic science areas, with limited resources dedicated to small sectors of forensic science such as fingerprints. The service would benefit greatly from a refocus of some of these activities towards e-forensics and DNA capabilities which are the emerging requirements of policing that are directly linked into the science strategy. HOSDB should work closely with ACPO in order to determine where the priorities are and how limited resources should be focussed under a commissioning process that is directly linked to the priorities identified and agreed by Chief Constables Council.

4. Future Requirements – The ACPO Perspective

4.1 In terms of the future, ACPO see no single solution to the issues highlighted throughout this response as there are a range of conflicting and interdependent factors to consider. That said, it may be possible to consider an approach that can satisfy the overall requirement using a range of co-ordinated solutions that utilise existing funding and resources in a more creative manner. This, coupled with potential government and European funding initiatives could provide a solid basis for research and development in not just forensic science, but the wider policing science community, eg social research and technological advances.

4.2 The most important factors within this area are the ability to co-ordinate activity, knowing who is doing what, when it will deliver and what it will

deliver. These are crucial to successful research and development. These specific initiatives and possible funding streams need to be explored further, however, they are interlinked, therefore, successful planning of activity is the key to delivering the Government requirements.

4.3 There needs to be a mechanism that can from a national perspective, have oversight of research and development activities, not necessarily to manage and control but to have strategic oversight, to ensure that activities are steered towards the requirements of the science and innovation strategy. At the present moment, the NPIA carry out this function to a certain extent, but with the remit extended to provide that oversight at the strategic level working in conjunction with ACPO and the Home Office, the situation could be greatly improved. This would ensure that there are direct linkages between academia and the CJS. One of the main benefits of developing a co-ordinated approach is that this will reduce the duplication of effort and funding towards programmes of work that have either been done already or have been completed and shelved as not meeting the requirement.

4.4 ACPO fully understands the complex landscape for forensic research and development and recognises that there are opportunities for improvement even in these difficult times. As previously stated, the Research Councils in the UK have access to substantial funding, however, there does need to be a link between the research activity and the requirements of Government. There should be some form of representation from the ACPO perspective on those panels making decisions on funding that have implications for crime prevention and public safety. This will ensure that the research commissioned will meet a specific public safety requirement, but should not be seen as a barrier to pure research. ACPO recognises the value in the development of pure research in order to extend the boundaries and this should not be restrained, however, this should be balanced against the requirement for solutions to short and medium term issues.

4.5 The maintenance of standards from both a technical and ethical position are critically important in the development R&D in forensic science. Technical standards will ensure that new developments that are introduced to the operational environment are assured, fit for purpose, and interoperable with other operational activity across all forces. The ethical standards will ensure that the developments are in accordance with the principles and conduct expected of applications within the criminal justice system. ACPO actively supports the maintenance of standards and will work with the Forensic Regulator and his team to ensure that these standards are maintained.

4.6 In the current fiscal environment, access to funding streams will inevitably see a reduction in capacity for R&D activities. This will mean that there will be more public scrutiny of what is being spent and where, and does it ultimately offer value for money. ACPO can provide the

strategic requirement to R&D activities for policing and support the academic community with direct access to policing problems. Academia should be well placed to respond to these problems utilising the wide range of disciplines available across the university network if they know where to direct activity. ACPO is uniquely positioned to provide that level of focus on behalf of policing utilising the full range of business area portfolios.

5. Conclusions

It is clear form the ACPO perspective that forensic science provides a valuable contribution to public safety through the delivery of safe and assured science. There are opportunities to build further capability in this area and this should be done with the seven guiding principles outlined in 1.5 of this document being paramount. There is some momentum gathering in the co-ordination of priorities with ACPO being assisted by the NPIA, but the closure of the NPIA should not be viewed as a barrier to its continuation. The co-ordination of efforts towards government priorities exist despite, not because of the NPIA and will remain to be an ACPO priority.

The ACPO view is that there should be some form of strategic oversight and formal links into the funders of research. This focussed research should be a blend of both applied, to deal with here and now issues as well as a long term strategy for pure science and horizon scanning for the future of forensic science R&D. The benefits derived form this approach will ensure that public safety and value for money will be at the forefront of the decision making process when the challenge of how to spend public funds.

ACPO will continue to develop the policing capability through the forensic portfolio structure and ensure that priorities are kept up to date. This will enable the forensic R&D community to remain in touch with the problems identified and utilise all their capabilities to respond to the challenges presented.

ADVISORY COUNCIL ON THE MISUSE OF DRUGS

Dear Professor Silverman,

The Advisory Council on the Misuse of Drugs (ACMD) are pleased to respond to the review of the UK's current and future provision of forensic research.

It is important that the ACMD continues to have access to high quality forensic science to ensure that it can provide advice to Ministers based on the best possible available evidence.

To support its work programme the ACMD gathers evidence from forensic providers concerning: analysis of drugs seizures; novel analysis and detection; and, also takes evidence directly from those involved with forensic research and development. In recent years the ACMD has received evidence from predominantly FSS and LGC forensics. In addition, the ACMD has received input via the UK Focal Point group concerned with early warning and the forensic providers that support this.

Although the detail of process is yet to be agreed by Parliament, the proposed Temporary Class Drug Orders, as part of the Police Reform and Social Responsibility Bill, the ACMD will provide advice to input to the Ministers considerations. It is therefore of paramount importance that forensic techniques and developments are available to detect and interdict the range of new psychoactive compounds as they may arise.

The ACMD would like to see a joined up approach to forensic science research, such that there is coordinated effort to ensure that forensic research matches priorities i.e. capability, efficiency, new and cutting edge research.

The ACMD welcome the review and look forward to the report of findings.

Yours sincerely

Professor Les Iversen

ANALYTICAL SERVICES INTERNATIONAL LTD

Contents

Questions for forensic science providers

The scale, scope and impact of the research and development carried out by forensic science providers and related organisations (in the public and private sector)

The Analytical Unit at St George's University of London is not only a university research group but also a forensic science provider. The Unit provides forensic toxicology services to coroners, the police, other forensic service providers, the legal profession and the public. The Unit is funded through its fee for service business and a partnership between St George's University of London (SGUL - http://forensic-toxicology.org/) and Analytical Services International Ltd (ASI Ltd – www.bioanalytics.co.uk).

Using the resources and expertise of ASI Ltd, the Unit has been a leader in the UK in the introduction and use of advanced analytical techniques such as liquid chromatography –tandem mass spectrometry (LC-MSMS) for forensic

toxicology. These techniques have been used to research and develop methods for the identification and analysis of emerging and new recreational drugs as well as improve the ability to detect drugs used to facilitate crime.

Questions for researchers

What work relevant to forensic science is being done in your group/university and what are the opportunities for the future?

The Analytical Unit at St George's University of London has been researching trends in, and epidemiology of, recreational drug use and abuse for over thirty years(Anderson et al., 1985). In recent years we have pioneered the collection of drugs from amnesty bins at dance venues and clubs as a new method to monitor the incidence and prevalence of drug use (Ramsey et al., 2001). This has allowed us to track the emergence of new drugs such as mephedrone (Wood et al., 2010a, Wood et al., 2010b)and the variability in existing and widely used drugs such as ecstasy in the UK (Wood et al., 2010c, Kenyon et al., 2005).

We have now extended our surveillance of the "drug scene" by test buying of so called "legal highs" from the internet (Davies et al., 2010) and have demonstrated that these purchases are far from legal (Ramsey et al., 2010). Our future plans include the further investigation of drug use in clubs and dance venues by measurement of drugs in sewerage and waste water, the exploration of "smart" drug use among students and to expand our existing interest in the national and international availability of substandard and counterfeit drugs (Kenyon et al., 2006).

What previous and current research partnerships do you have with forensic science providers, police forces, the National Policing Improvement Agency, etc.?

To further our research into the epidemiology of recreational drug use and abuse the Toxicology Service of the Analytical Unit at St George's University of London has formed an informal cooperative research grouping with

- Analytical Services International Ltd, London
- Clinical Pharmacology, Barts and The London School of Medicine and Dentistry
- Clinical Toxicology, Guy's and St Thomas' NHS Foundation Trust, and King's Health Partners, London
- Chemistry Department, Kingston University, Kingston, Surrey
- HFL Sport Science (formerly the Horse Racing Forensics Laboratory), Newmarket
- The Forensic Science Service, London
- TICTAC Communications Ltd, London

To expand our interest in substandard and counterfeit drugs the Analytical Unit hasresearch partnerships in this area with two major pharmaceutical companies, Novartis and sanofi aventis. The Unit is also developing networks of concerned scientists in the 2nd and 3rd Worlds through the numerous ex-students and contacts made through the IATDMCT.

Can you give good examples in the forensic science field of translation ofresearch into practice, and also any examples where this has been difficult or problematic?

Two of the major issues in tracking, detecting and measuring the emergence of new recreational drugs are the dissemination of accurate information on their chemical structure and effects, and the provision of analytical standards of known purity. Through our association with TICTAC communications the former has been achieved and in cooperation with the Chemistry Department at Kingston University we have been able to provide the latter by synthesis of, and chemically characterise material of known composition and purity.
The information collected by ASI Ltd and SGUL can be used to assess the harm caused by recreational drug use and inform government and health policies (Ramsey et al., 1999,Anderson et al., 1985).

What do you see as the opportunities for, and the barriers to, the funding of research relevant to forensic science?

The major problem with funding research relevant to forensic toxicology is that it falls between several stools. It is not seen as basic research that could be funded by the MRC or the Wellcome Trust, for example. Nor is it seen as health service or healthcare research that would be funded by the NHS or Department of Health through the National Institute for Health Research (NHIR) programmes. It is unclear who should be funding our important observational research.

Another issue is that the “market” created by the last government has resulted in a reluctance of forensic providers to cooperate as they perceive they may be giving away a competitive advantage. Additionally, market forces have made research a luxury that many laboratories can no longer afford as it is unfunded and there are not sufficient surplus funds available to support the activity.

What are the important international networks and how useful are they? Do you have any specific international collaborations you would wish to draw to our attention?

The staff of the Analytical Unit are involved in several national and international collaborations. Nationally they are involved in running the London Toxicology Group and participate in the UK Forensic Toxicology Network. Professor Johnston is an executive board member of the Academy of Forensic Medical Sciences and regularly reviews articles for Science Medicine and the Law and the Journal of Forensic and Legal Medicine.

Internationally Professor Holt is a past president of the International Association of Therapeutic Drug Monitoring and Clinical Toxicology (IATDMCT) and Professor Johnston a past director of education. Both are founder members of the association and are editorial board members of the association’s journal, Therapeutic Drug Monitoring. Other staff members in the Unit are active in running the young scientists’ forum and the association’s newsletter. Through its network of scientists and regular meetings, the IATDMCT has fostered many useful collaborations and educational opportunities in forensic and clinical toxicology.

The international collaborations with Novartis (USA & Switzerland) and sanofi aventis (France) have enabled the Unit to expand its work in the area of substandard and counterfeit drugs.

Are there any other issues relevant to our terms of reference that you would wish to comment on?

No.

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ASSOCIATION OF FORENSIC SERVICE PROVIDERS' BODY FLUID FORUM

We are grateful for the opportunity to contribute to the Review of research and development (R+D) in forensic science.

The Association of Forensic Service Providers Body Fluid Forum (AFSP BFF) is a sub group authorised by the AFSP board. It is a working group of operational forensic biologists representing each of the following public and private sector organisations:

- Cellmark Forensic Services
- Forensic Science Laboratory, Dublin
- Forensic Science Northern Ireland
- Forensic Science Service
- Key Forensic
- LGC Forensics
- Scottish Police Services Authority

These organisations provide the majority of the mainstream forensic science provision to Police Forces in the United Kingdom and Republic of Ireland. The AFSP BFF was set up eight years ago as a result of the founder member representatives recognising a need for such a group and it meets at least three times a year. It is characterised by the passion, drive and determination of its member representatives who, with the support of their organisations, collaborate to improve the value of body fluid evidence within the Criminal Justice System (CJS).

A formal agreement drawn up by the group detailing what information can be shared illustrates the scope of AFSP BFF (see Appendix). The group is designed to complement work carried out in the member organisations. It is the holistic scope and the very applied viewpoint of member representatives that makes the group so effective in supporting the entire R+D process - generating relevant ideas for research, acting as a sounding board for external groups, championing the appropriate development of current methods, commissioning and collaborating on R+D projects, supporting the introduction of new methods and developing the understanding and data collection necessary to interpret case findings for the CJS. It is hoped that this document will highlight the importance of the development side of R+D (and interaction with practitioners), which is to date the main focus of the AFSP BFF.

1. The scale, scope and impact of the research and development carried out by forensic science providers and related organisations

Scale:

Member organisations support the member representatives comprising the AFSP BFF in order to disseminate information, complete actions and carry out collaborative research. Commissioned and collaborative projects involve further caseworkers on an ad hoc basis and are carried out in the members' laboratories with procedures and equipment currently used in routine casework. There is currently no additional dedicated budget.

Scope:

Topics of recent and current interest include:

- Collaborative research into the transfer and persistence of DNA (the AFSP BFF social contact DNA project).
- Collaborative validation (including working with the manufacturer) of a new test for the presence of urine.
- Collation of validations on tests for azoospermic semen.
- Sharing of research into:
    - Recovery of body fluids from skin.
    - Recovery of semen from sanitary products.
    - Secondary transfer of wet and dry semen.
    - Persistence of semen on condoms.
    - Methods to detect blood on dark items.
    - Prevalence of DNA on fingernails.
- Presentation by Kings College London of their 'Light It Up' project for body fluid identification.

We have compiled a list of over twenty prioritised R+D projects yet to be started covering the following:

- Improving the identification of body fluids.
- Sampling methods for body fluids and DNA.
- Transfer and persistence studies for body fluids and DNA.
- A National Database for the collection of sexual assault data.
- Collection of other data to assist the interpretation of findings.

In many cases, the value of forensic science to the criminal justice system derives from the added interpretation provided by a forensic expert which puts the analytical results into context within the case. Projects such as the AFSP BFF social contact DNA project have provided data to assist with such

interpretations; however even within our collaborative group we are only able to progress projects on a relatively small scale. It is vital to maintain continuing input and focus from practitioners and working groups to ensure that forensic interpretation is given due consideration in the research environment.

Impact:

The net result of the AFSP BFF has been to identify and improve best practice for the recovery, identification and interpretation of body fluid evidence, ultimately increasing the likelihood of evidence detection in cases and improving the value of body fluid evidence within the Criminal Justice System. Other benefits of the group are highlighted in specific examples given below:

- A collaborative trial into the extraction of intimate swabs from medical examinations and clothing led a number of recommendations and changes in operational procedures for member organisations. This work was published.
- Research into refining the test for the presence of semen resulted in semen being detected in a greater number of sexual assault cases. Some of this work is pending publication.
- Member organisations have recently collaborated in a joint validation exercise for the RSID^{TM} urine test kit. This has shared the cost of the validation, prevented duplication of effort and, with further work, may lead to the introduction of this new kit.
- All members are currently participating in collaborative research to address the likelihood of female DNA transfer to male underwear as a result of social rather than sexual contact. This has allowed access to a large pool of potential donors (a limiting step in some research), shared the cost of the exercise (which included over 300 DNA tests) and provided some much needed data. This work will be presented at the second AFSP BFF conference in September 2011.
- Sharing papers once accepted for publication and the results of research projects from member organisations (many of which may not result in publication) has prevented duplication of work, raised awareness and supported the introduction of new scientific methods into casework (such as the use of minitaping to recover cellular DNA).

The AFSP BFF publishes papers and internal technical notes on research and literature searches. It is an established network for disseminating information through member organisations. The group holds a vast library of information

for member representatives on topics discussed in meetings and information shared and provides an effective support network for its operational scientists. Member representatives have presented at UK and European conferences. The first AFSP BFF conference brought together scientists from the UK and beyond.

Partnerships:
The AFSP BFF in itself is a large R+D partnership. It provides the opportunity for external bodies to access all of the member organisations. Member representatives have forged links with universities, manufacturers and colleagues farther afield.

The AFSP BFF has representatives on and has provided advice to the Forensic Science Committee of the Faculty of Forensic and Legal Medicine, which is a group comprising medical examiners, medical kit manufacturers and FSPs. Involvement with this group has included collaborative authorship of a chapter in a textbook on best practice in sexual assault medical examinations.

Funding:
Currently the AFSP BFF member organisations fund their representatives, its meetings and any collaborative research.

The list of over twenty research projects yet to be started will be assessed to determine the most suitable place for the research to be carried out - in individual FSPs, by collaboration between some or all AFSP BFF organisations, with the proposed provision of a joint AFSP BFF researcher or via external bodies including academia.

Routes for external UK funding are not clear. Some funds may be available in Europe (European Commission FP7) but would involve linking with other European organisations. The AFSP BFF would welcome access to funding in the UK. Funding would undoubtedly increase output from this group (see Scope).

2. The extent and ways in which forensic science practice assesses the relevance of, and accesses, latest advances in technology and techniques

Contact with the AFSP BFF allows ready access to all of its member organisations. We review published work for new developments, have developed links with manufacturers and can act as a conduit to assess the relevance to casework of new or proposed research from universities and to back funding proposals.

New scientific methods require publication, in house validation, accreditation to ISO 17025 (or similar) and scrutiny by the CJS.

3. The scale and scope of forensic science research undertaken and its links with forensic science practice.

The AFSP BFF has spoken with / provided input into / offered to back requests for funding from the following organisations:

- Kings College London.
- Strathclyde University.
- Dublin City University.
- University of Zurich.

We have received advice from the University of Lausanne, Strathclyde University, Advance Forensics and members of the Forensic Regulators' Interpretation Group on an AFSP BFF collaborative research project.

Other universities have also expressed an interest in providing an academic research capability to the group. We welcome collaborations.

Abstracts from BSc and MSc projects carried out in member organisations are shared within the group.

4. The current and potential contribution of international networks to UK forensic science research and practice.

As an established network of UK and Republic of Ireland providers the AFSP BFF recognizes the enormous benefit of such groups. The AFSP BFF was invited to present on its work to the European Network of Forensic Science Institutes, however ENFSI does not currently have a body fluid working group.

At present we have limited interaction with colleagues in other countries. We would welcome development of and links with similar networks.

The AFSP BFF provides an effective model as a working group to provide an active focus on the contextual development of existing methods and forensic

interpretation, and a pathway for advice and/or collaboration on new research which is directly relevant to forensic casework.

AFSP BFF * April 2011

Appendix

The AFSP formally agreed that the following information can be shared between AFSP BFF members.

- Abstracts of MSc student projects.
- Learning points from problems encountered in casework.
- Learning points from proficiency trials.
- Procedures of established methods and the validation carried out for the same.
- Interpretation guidelines for established procedures.
- Results of research carried out in member organisations to improve established methods and the interpretation of results:
    - This excludes commercially sensitive research, blue skies research or matters pending patents.
    - It does include aspects related to everyday casework where the criminal justice system benefits from the sharing of scientific information.
- Details of research accepted for publication.

Unless otherwise agreed, anonymity is provided for contributors.

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Julie Allard and Geraldine Davidson (Joint Chair AFSP BFF)

CCL FORENSICS

1. The scale, scope and impact of the research and development carried out by forensic science providers and related organisations (in the public and private sector).

Scale of R & D: e.g. your research budget; capital investment in R & D; size of research workforce; details of dedicated facilities.

CCL-Forensics currently employ 4 full time staff within its Research and Development function. This team is dedicated entirely to Research and Development projects and has an annual directly attributable budget in excess of £135,000. Whilst our R&D activities require minimal capital investment (less than £5k per annum), other indirectly attributable costs for testing developed applications and utilities are estimated to cost the business an additional £50,000 per annum.

Scope: e.g. topics of recent and current interest in your own organisation's research; suggestion of any areas where you feel more research would be useful.

CCL Forensics research is focussed on our key business technology areas –

- Mobile Devices (mobile telephones, tablet computers ETC)
- Computers
- Cell Site Analysis
- Satellite Navigation

A small proportion of research is targeted at other technologies that have the potential to yield evidence. For example an ongoing project is examining the data available from electronic systems embedded in motor vehicles.

There are a number of criteria that are set before adopting a project. These are linked to high level business objectives and take account of perceived trend in relevant technology. A project should meet one or more of these to justify adoption. These are:

- Would the project add value to the output of our analysis by developing tools and techniques that enhance the **presentation** of data to the end user
- Would the project drive forward our knowledge of, and ability to recover and present data from, the key **smartphone** platforms – Apple iOS, Android and RIM Blackberry
- Would the project expand our capability in respect of **mobile devices** to ensure that CCL-F has the capability to recover data, including deleted wherever possible, from key devices (key = either most frequently encountered or those associated with significant cases)
- Does the project enable a task to be automated – delivering a **time saving** and or an improvement in accuracy

- Would the project enable us to exploit **new evidential opportunities**

Projects vary in scale from a few hours to more than a year.

Topics which have been subject to research during the previous twelve months include –

- SQLite forensics
- Google's Android operating system
- Apple iPhone
- Apple iPad
- Recovering deleted data from a wide range of mobile telephones
- Automating the normalising of Network call data records to facilitate more efficient cell site analysis
- Producing a phone data analysis tool enabling multiple handsets to be investigated simultaneously
- Developing a tool to handle Apple p-list files
- Developing a cell site surveying tool

Impact: e.g. examples where your research has had impact, or will have obvious impact, on forensic science provision and practice.

The key goal of our Research & Development is to be able to identify, recover and present as much of the relevant data that is present on the device as possible. Because of the wide variety of ways that data can be stored on an increasingly wide range of devices this can be extremely challenging and there is certainly no magic bullet.

A good example of how our research has had an impact relates to our research into SQLite databases. These are encountered widely throughout the information technology arena and can be found extensively in popular products such as Apple's iPhone and iPad as well as their computer operating system and Safari Internet browser software; Google's Android phone operating system and Chrome browser software and a wide range of mobile applications. Such extensive use of SQLite databases presents a huge reservoir of potentially relevant data.

The 'live' data in the databases can be read using commercially available tools. However, our researches revealed that, as a result of the way the database functions, it was possible to recover data that was no longer referenced by the database including entries that have been deleted. Having, through research, understood how the database behaves we have been able to produce our own software to automate the process of forensically recovering and presenting data from SQLite databases.

A further example concerns our research into web cache on mobile telephones and other mobile devices (for example the iPad and other tablet

computers). Web browsing is now commonly done on mobile devices, presenting a wealth of potentially relevant evidence, and yet commercially available tools do not decode or present the data. The function is limited to recover the raw files that contain this information.

We have invested considerable resources into reverse engineering the formats of a web cache files from a range of browser software used in mobile devices. Understanding the format enables us to re-build the web pages visited presenting compelling and easily understood evidence. We've now written software to automate this process and estimate that we can now decode web cache for more than 80% of mobile devices on the market today.

Partnerships: to include details of research and development partnerships, both in the UK and abroad. (Also relevant to items 3 and 4 below.)

We have not had any research partnerships to date. However, we are in the final stages of negotiating an arrangement with a university to employ a PhD student on a specific large-scale long-term project requiring specialist skills and knowledge.

Funding: to include details of externally funded projects, source of funds, project scope, time scales and progress. (Also relevant to item 3 below.)
To date all research & development has been entirely funded by CCL-Forensics. We are however currently engaged in talks with third parties that could provide some external funding.

The first involved a third party company specialising in providing services to the insurance industry. They like one of our R&D idea and can see significant market potential in their core market. Negotiations are ongoing but may result in a direct cost contribution to fund a dedicated researcher.
The other opportunity relates to a long term R&D project in respect of which we are hoping to enter into a Knowledge Transfer Partnership (KTP) with a leading university. The University will fund half of the cost of a PhD student who is dedicated to the project. The KTP scheme facilitates the development and transfer of knowledge from academia to the private sector to facilitate the commercial exploitation of that knowledge. This is a promising route for future research collaboration.

2. The extent, and the ways in which, forensic science practice assesses the relevance of, and accesses, the latest advances in technologies and techniques.

How do you bring current scientific developments into practice? Please explain any mechanisms and/or give examples. Are there any barriers to this process?

The main barrier to brining new advances into practice is testing. The more complex and or extensive the potential use of an advancement the more challenging the testing process. It can be incredibly difficult to test even a small percentage of the potential scenarios in which a piece of software might

be used. For example – our SQLite software – there are an unlimited number of potential database structures and it is impossible to test every one. Nor can we realistically test software in all the operating environments likely to be encountered over time.

3. The scale and scope of forensic science research undertaken in academia and its links with forensic science practice.

What links, if any, do you have with academia, and what value do you place on these? Please also comment on the value of academic work to your business, whether or not it is part of a specific or explicit link.

We have made overtures to a number of academic institutions and have been generally disappointed with the response. We appreciate there are issues relating to the ownership of the intellectual property right arising from research that acts as a barrier to more cooperative research with academia.

I have referred to a large scale project we're currently negotiating with a leading university above.

4. The current and potential contribution of international research networks to UK forensic science research and practice.

Please give any specific examples or comments.

There are few research networks, international or otherwise, in digital forensics. There are some informal networks that make valuable research information freely available but to an extent, this is reliant on the individual being willing to share and is in no way structured.

Where formal networks do exist there can sometimes be a 'law enforcement only' attitude that restricts the value of the information being shared.

Mark Larson – Forensics Manager
CCL Forensics | 36 Cygnet Court, Timothy's Bridge Road, Stratford-upon-Avon CV37 9NW

CELLMARK FORENSIC SERVICES

Cellmark Forensic Services

Declaration of Interest

1. Cellmark Forensic Services (Orchid Cellmark Ltd) is a private forensic company currently working under contract with over 50% of the police forces in England and Wales. Cellmark supports the investigative process from the provision of forensic scientists to assist the police at crime scenes, through to the delivery of expert testimony in court. We provide a wide range of laboratory tests and analyses from specialist DNA testing to the provision of a comprehensive range of forensic techniques used in the investigation of serious offences (forensic casework).

Cellmark employs approximately 350 people, primarily involved in forensic analysis, at our facilities in Abingdon, Oxfordshire and Chorley, Lancashire. Established in 1987, Cellmark received a Queen's Award for Technological Achievement in 1990 and has over two decades of experience of designing and delivering high quality forensic analytical services in the UK, accredited to international quality standards.

Questions for forensic science providers

The scale, scope and impact of the research and development carried out by forensic science providers and related organisations (in the public and private sector).

Scale:

2. Orchid Cellmark Ltd is UK registered company that is a wholly owned subsidiary of Orchid Cellmark Inc, whose headquarters are in Princeton, New Jersey, USA. In the US, Orchid Cellmark Inc provides forensic and relationship testing services from laboratory facilities at Dayton, Ohio and Dallas, Texas, the latter site housing a dedicated R&D team. In the UK Orchid Cellmark Ltd's R&D team is based at its Abingdon facilities.

3 In 2010 the Company's R&D programme was delivered with a combined research budget of approximately £1 million. Ten dedicated scientists are supported by additional resource from a team of information technology developers and operational development scientists involved in project work.

Scope:

4. Driven by customer requirements, a major focus of our R&D is process development to enhance forensic effectiveness, reduce costs and improve the speed of service delivery across our range of forensic services.

5. A significant proportion of our effort is spent on the development and validation of improved methodologies covering the following areas:

- Enhanced recovery and detection of body□fluids
- Crime scene mark enhancement techniques□

- Improved DNA recovery from a wide range of materials
- Improved methods for low template DNA analysis
- Interpretation of complex DNA results
- Improved algorithms for familial searching and complex mixture analysis
- An extended range of DNA and RNA marker systems

Impact:

7. The impact of our investment in process improvements over the past five years has been clearly demonstrated by the vastly improved response time for police forces for services ranging from DNA profiling of crime stains for submission to the National DNA Database® to delivery of complex case results. At the same time the cost of service provision to police customers has been significantly reduced. Our ability to process complex forensic exhibits with rapid turnaround times has also enhanced our ability to provide a rapid UK response to terrorist and mass disaster incidents.

8. Cellmark's research into improved DNA profiling detection sensitivity (DNA enhancement techniques) has had a significant impact on the success rates of obtaining DNA identification information from low levels of DNA. Specifically this research had a major bearing on the final resolution of the Rachel Nickell murder case and directly led to the re-evaluation of DNA work carried out in a large number of serious offences previously analysed using Low Copy Number (LCN) analysis (Operation Cube).

9 The development of improved methods for recovery of sperm cells from medical examination swabs has enabled us to extend the evidence detection window in sexual offence cases.

10. Investment in the analysis of forensic outcome data, supported by targeted scientificdevelopment projects, has positively contributed to evidence recovery and DNA profiling success rates, police forensic awareness, and to the investigative decision process which has helped to deliver improved value in terms of forensic spend and analytical outcome.

Partnerships:

11. Cellmark is a member organisation of the Association of Forensic Science Providers (AFSP); its scientists are represented on its Body Fluid Forum working group who are actively involved in collaborative, applied research and validation activities.

12. Links with Academia include hosting MSc studentships through relationships with King's College, London, University of Strathclyde, Glasgow and University of Central Lancashire. We have also been involved in providing lecturing input into University forensic science courses.

13. We have a number of commercial collaborations and relationships with companies involved with technology development of interest to the forensic arena.

14. We regularly collaborate with police forces to investigate improved evidence collection and recovery, and forensic analysis.

15. Outside the UK we maintain informal dialogue with several forensic institutes on topics of mutual interest as well as engaging with research collaborations.

Funding:

16. We have no current access to external funding sources.

The extent, and the ways in which, forensic science practice assesses the relevance of, and accesses, the latest advances in technologies and techniques.

17. While the science of some forensic disciplines has changed little in recent years, significant developments have been made in other areas, particularly DNA and analytical instrumentation. Regular review of the scientific literature, attendance at relevant conferences and close dialogue with equipment and technology manufacturers identifies new scientific developments and analytical approaches and provides early access to new products. Forensic service providers have a particular strength in assessing the potential practical forensic application for new technologies and instrumentation, assessing their robustness for use in the criminal justice process and providing late stage validation for operational use.

18. There are significant challenges in bringing new forensic science techniques into practice. In addition to the rigorous validation required to achieve ISO17025 accreditation for new methods and processes, police and legal acceptance must be achieved despite the absence of a clear framework that defines how new techniques should be brought to court – an area that the Forensic Regulator is seeking to address. New methods require peer review, publication and disclosure to enable the defence to perform independent evidence analysis.

The scale and scope of forensic science research undertaken in academia and its links with forensic science practice.

19. As noted above we do maintain links with several academic institutes, often through forensic practitioners who have taken up an academic position. However links with academia are not particularly strong or developed. We believe that there is a greater potential for productive partnerships with academia particularly if academic institutes can access early stage research funding, with forensic providers bringing their practical forensic experience to the assessment and development of a technique for use within the criminal justice process, and contributing towards its validation.

The current and potential contribution of international research networks to UK forensic science research and practice.

20. We believe that at present the wider European and international forensic science research community provides minimal input to the UK. Historically the FSS has played a major role within the International forensic community and a single UK supplier of its size and influence also provided good access into research networks and collaborations such as ENFSI (European Network of Forensic Science Institutes). Over the past five years the changing nature of the UK forensic market has had its impact on the relationship of UK Forensic Science with the International community and this will no doubt continue to evolve.

21. The International Society of Forensic Genetics is a useful network whose meetings and working groups we subscribe to and participate in.

22. In the UK the Forensic Regulator's Specialist Working Groups have initiated a useful network forum for sharing best practice.

April 2011

David Hartshorne, Commercial Director.
Roger Derbyshire, Operations Director.
Cellmark Forensic Services, 16 Blacklands Way, Abingdon Business Park, Abingdon,
Oxon OX14 1DY. Tel: 01235 528609.

CROWN PROSECUTION SERVICE

Dear Professor Silverman,

RE: Review of Research and Development in Forensic Science for the Criminal Justice System

Thank you for your letter of 14 February 2011, addressed to the Director of Public Prosecutions regarding the Review you are conducting. I am responding on behalf of the Director as the Senior Policy Adviser with the national lead for the Crown Prosecution Service (CPS) on forensic science issues.

You may find the attached summary note of our broad views and core principles on the use of forensic science in the prosecution process of interest. This note has been written with particular emphasis on the issues relating to the changing marketplace since the closure of the Forensic Science Service was announced in December 2010. I would be pleased to meet you and discuss these core principles further in the context of future forensic research and development proposals.

Perhaps you would be kind enough to indicate a date when a meeting would be convenient for you. I can be contacted on Karen.squibbwilliams@cps.gsi.gov.uk .

I look forward to hearing from you.

Yours sincerely,

Karen Squibb-Williams
Strategy and Policy Directorate

THE MARKET PLACE, FORENSIC SCIENCE AND THE CRIMINAL JUSTICE SYSTEM

The Market Place, Forensic Science and the Criminal Justice System in 2011

Providing Forensic Science Services to the Criminal Justice System: Navigating the Market and Core Foundation Principles Driving Outputs

a) The Criminal Procedure Rules (2010)
b) Streamlining Forensic Case Management (CJSSS);
c) The Code for Crown Prosecutors;
d) Crown Prosecution Service (CPS) Core Quality Standards; and
e) The absence of a contractual relationship between provider and end users, namely CPS and the courts

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a) The Criminal Procedure Rules (2010)

The Criminal Procedure Rules (CrPR) were issued in 2005 and consolidated in April 2010. They apply to **all** participants throughout the conduct of a criminal case. Of particular relevance to forensic science service providers are:

- Part 1: The Overriding Objective
- Part 3: Case management: Identification of the Issues
- Parts 21 & 22: Disclosure
- Part 33: Expert Evidence

b) Streamlining Forensic Case Management (SFR)

A method of using consistent national case work principles and forms to implement the requirements of the Criminal Procedure Rules when using forensic science in the criminal justice system. It enables early identification of any forensic issues (CrPR, r3) to take place much sooner in the case preparation process. It is a separate requirement to the CPIA, s5 Defence Case Statement. The process also facilitates better compliance with CrPR,r33 wherein expert witness obligations and duties of disclosure are engaged much earlier in the process than previously (see MPS DVD).

c) The Code for Crown Prosecutors (6th Edition)

The statutory Code that all Crown Prosecutors in England and Wales (along with a number of other prosecuting authorities) must apply when considering every prosecution throughout the life of the case. The test within the Code for Crown Prosecutors has two stages:

- The Evidential Stage, and
- The Public Interest Stage

The Evidential stage **must** be met before the Public Interest stage can be considered.

d) The Crown Prosecution Service Core Quality Standards (2010)

There are 12 Core Quality standards which set out what the CPS does, how it makes decisions and what can be expected of the Service.

Both publications can be found in full on www.cps.gov.uk

e) Contracts, criminal law and the adversarial system:

- The distinction between criminal and civil justice systems must be recognised by commercial forensic science providers.
- This is particularly relevant where the scientific providers are based elsewhere in Europe and may not be familiar with or structured to accommodate the Common Law *adversarial* system in place in England and Wales.
- Specific rules apply in relation to the admissibility and reliability of evidence, along with the full disclosure of unused material - that is, any material relevant to the investigation that is not used as evidence.

The five Key requirements for forensic science providers arising from the above Core Foundation Principles are:

1. To **comply** with the Codes of Practice set down by the independent Forensic Science Regulator.

2. To **ensure** Quality Standards and Assurance processes are applied which are nationally consistent and compliant with appropriate ISO standards, United Kingdom Accreditation Service (UKAS) accreditation, EU directives and clear development and validation processes.

   .

3. To **provide** clear communication and interpretation of scientific processes, procedures, strengths, weaknesses and meaning. This should be set down on a short (approximately 2 pages) guide in layman's terms to the key services being offered accompanied by a Q & A style document illustrating the strengths and weaknesses of the scientific procedures offered.

   Not all Crown Prosecutors will necessarily have a detailed knowledge of forensic science. These documents will assist Prosecutors who are effectively 'gatekeepers' in the prosecution process when applying the Code for Crown Prosecutors, the CPS Core Quality Standards, and the CrPR 2010 to investigations and subsequent prosecutions.

4. To **engage** with the national Streamlined Forensic Reporting (SFR) process (previously referred to as Staged Forensic Reporting, first introduced in 2004). Revised guidance and forms have been produced (though not yet published) for 2011.

5. To be fully **aware** of and compliant with Disclosure and Expert Witness obligations (explanatory booklet available from the CPS website), including the disclosure of details of algorithms and statistical analysis, and without regard to commercial sensitivity. Following appropriate full disclosure of this information to the police and prosecution, the Court process allows for applications to be made to treat certain commercial information as 'sensitive'. Any breach of such an order is actionable.

Comply Ensure Provide Engage Aware

DSTL

Re: Review of research and development in forensic science
Many thanks for the invitation to contribute to the Home Office review of R&D in forensic science. Please find enclosed comments relating to the current status of R&D conducted within the Forensic Explosives Laboratory (FEL).

FEL is part of the Defence Science and Technology Laboratory (Dstl). As a Forensic Science Provider (FSP) it provides an operationally responsive service to UK police forces, UK governmental departments, foreign governments and other *bona fide* clients, with respect to the forensic investigation of explosives related crime and terrorism. FEL investigates around 200 – 250 forensic cases per year. Management and operational delivery of the forensic service is governed via appropriate organisational and individual competence measures, which are achieved through accreditation to the ISO 17025 standard by the United Kingdom Accreditation Service (UKAS).

I hope the information is of use. Please do not hesitate to contact me, on behalf of FEL, if I can be of any further assistance.

Yours faithfully,

Dr Matthew Beardah
Principal Scientist (Forensic Explosives Laboratory)

Home Office review of research and development in forensic science
Contribution from Forensic Explosives Laboratory
March 2011

The Dstl Forensic Explosives Laboratory (FEL) has a dedicated R&D programme that aims to deliver reactive R&D activities to improve the

responsiveness of operational forensic casework, alongside longerterm R&D to meet potential future requirements of the forensic service, i.e. addressing capability deficiencies, changing threat, evolving technology, regulation, etc. The programme isconducted by a team of 8 – 10 staff that are educated to degree level in chemistry.

The R&D programme is directly funded entirely by the Home Office, currently at about £500 k per year. Home Office capital investment in the FEL forensic capability is also about £500 k this year, although this may be cut in future years due to budgetary pressures. Much of this investment has related to maintaining state-of-the-art analytical equipment, which, of necessity, requires appropriate method development, validation and accreditation2,3 according to the ISO170254 standard. Formally, FELs R&D effort focuses upon three principal themes;

• **Explosives analysis:** Developing validated analytical techniques for explosives identification, suitable for ISO17025 accreditation.
• **Forensic methodology:** Applying forensic methodology for the collection and processing of explosives containing samples.
• **Threat assessment:** Assessing the explosives threat to inform the explosives analysis and forensic methodology R&D programmes. These relate to the objective of providing a forensic service that adds significant value, reduces operational turn-around times and anticipates and makes provision for future threat materials. As policy, FEL aspires to integrate the latest, commercially available, advances in technology into the forensic capability. It does this via a number of managed activities, e.g. technology watch / horizon scoping, through a dedicated focus group that manages through-life capability development, i.e. innovation, R&D, procurement, implementation and quality maintenance, and through interaction with appropriate academic, industrial and forensic partners. Barriers to successfully managing FEL through-life capability development often centre upon having sufficient staff resources to conduct the level of R&D required to support FELs operational and quality/regulatory requirements.

While the impact of FEL R&D is largely supportive of enhancing the forensic capability, FEL actively promotes the sharing of its work through publication in peer-reviewed journals5-27 and appropriate conferences. By doing so, the impact on the wider forensic explosives community is significant, helping to maintain our position and reputation as a leader in the field.

As an FSP in the discipline of explosives investigation, FEL engages with a wide number of analogous national and international FSPs in relation to a variety of core business activities, including quality management, forensic operations and capability development. In terms of R&D, this is largely conducted by sharing information through the ENFSI Expert Working Group on Explosives, which FEL heavily supports and influences. Through this network, FEL leads a project group that aims to share current R&D information across the community, as well as facilitating collaboration. Recently, FEL has collaborated with the Federal Bureau of Investigation (FBI), Netherlands Forensic Institute (NFI) and Swiss Scientific Research Service on

a number of mutual R&D interests, including assessing emerging technologies and developing common methods of explosives analysis. Within the UK, FEL has conducted previous collaborative research with the Forensic Science Service (FSS), investigating combined protocols for post-explosion evidence recovery, e.g. DNA, explosives and fingerprints.

Historically, FELs R&D links with academia have been a relatively small part of the overall programme, because the majority of FELs R&D effort supports an operationally responsive service that is best conducted *in-house*. The in-house R&D also provides an essential platform to train prospective FEL case officers, given the ever changing explosives environment FEL faces. However, collaborative research with academia is highly valued by FEL (and Dstl) as it supports longer-term capability building, potentially using areas of expertise that are not held within the group. Indeed, a number of joint R&D activities have been beneficial in recent years. In collaboration with Queens University Belfast (QUB), through a Dstl sponsored PhD studentship, FEL has conducted fundamental research focusing upon determining shifts in isotopic signatures between precursors and explosives products during synthesis.

Although at a relatively immature stage, such work could have a significant longer-term impact as a discriminatory analytical tool in the forensic community. A three-year EPSRC funded project with the University of Manchester focused on developing miniaturised methods of analysis for explosives using isotachophoresis (ITP), with a view to applying the technology to field-based screening equipment. Other collaborative work, conducted with the University of Sunderland, has involved investigating the structural properties of TATP using hyphenated chromatography and nuclear magnetic resonance (NMR) spectroscopy techniques. FEL also has strong links with the University of Strathclyde and Kings College London, taking placement students to conduct short-term research projects within FEL in support of their MSc chemistry and forensic science programmes.

Dr Matthew Beardah
Principal Scientist (Forensic Explosives Laboratory)

FACULTY OF FORENSIC AND LEGAL MEDICINE OF THE ROYAL COLLEGE OF PHYSICIANS

Review of Research and Development in Forensic Science

Thank you for inviting comments on the above review.

The Faculty of Forensic and Legal Medicine was established in April 2006 and has been founded to achieve the following objectives:

- To promote for the public benefit the advancement of education and knowledge in the field of forensic and legal medicine;
- To develop and maintain for the public benefit the good practice of forensic and legal medicine by ensuring the highest professional standards of competence and ethical integrity.

The Faculty includes three different professional groups:

- Forensic practitioners
- Medically qualified coroners
- Medico‐legal advisers to the medical defence organisations.

The Faculty believes that it is important that forensic science works in close collaboration with forensic medicine as advances in each are less likely to occur in isolation. This is exemplified by the existence of close collaboration and networking in the fields of DNA, toxicology, scenes of crime etc. If the Faculty can be of further assistance, please do not hesitate to contact me.

Yours sincerely

FORENSIC ACCESS LTD.

REVIEW OF RESEARCH & DEVELOPMENT IN FORENSIC SCIENCE – RESPONSE FROM FORENSIC ACCESS LTD.

Introduction

Forensic Access is a relatively small commercial forensic consultancy based in Oxfordshire; founded in 1986, and serving the CJS. The company's roots were originally entrenched in Defence work, though more recently since a new team took over in 2007 it now works for the Defence and Prosecution assisting with many of the high profile cases in the UK and under the banner of ISO 17025. The team members have all worked at some stage in their career for one or more of the larger UK forensic providers, in both operational forensic casework and in research. Since its inception Forensic Access has always had a toe in R&D and ensured a working environment to allow students to take up programmes of work with us as part of their academic development.

Our response is geared towards general comments as opposed to specifically answering your questions. We consider our contribution will be relatively low key compared to the larger providers purely based on the scale of operation and market share.

Structure of our R&D Programmes:
Wherever possible we like to see a close relationship between academia and a forensic provider. Our experience suggests one without the other does not bode well for credibility or the dovetailing the development into casework. Over the years, Forensic Access has worked with many Universities that we consider are offering credibility to our profession – those we have worked with most include: Strathclyde University, Kings College, South Bank University, Huddersfield University, Northumbria and Teeside University.
We also see advantage in pulling in additional scientific "partners" [non-forensic] and/or process managers depending on the specifics of the scope of research.

The R&D in Forensic Access is managed by our Science Committee and we annually put together any projects we feel will be beneficial to either the company *per se* or the profession as a whole. A business plan is pulled together in line with the project and the Forensic Access Board has the final say as to whether or not to proceed.

We sit on the approved Framework of forensic suppliers for NPIA though we don't currently have a contract with a police force. As such our research topics tend to be focussed on casework areas we feel would resolve issues that arise in interpretation and evaluation of evidence.

Areas requiring attention
We would be particularly supportive of more development of forensic databases to which all providers had access. We also consider that more work is required surrounding models used to assess the value of evidence – to us these appear to be formulated on the grounds of being non-biased but the tools used to achieve the resulting phrases of evidential support are heavily reliant of events as seen by those working for the prosecutor.

Concerns

We are aware that the main forensic providers feel uncomfortable in having to share, under the guise of the police contract, their R&D projects and outcomes with the NPIA. Forensic Access has sympathy here with the other providers and we would feel less inclined in passing on potentially commercially sensitive information to NPIA as they too have a commercial stake in the market.

We should like to see the emergence of a new model which is proactive in engaging the main providers, academia and the HO Chief Scientist to seek funds for joint projects. However, now the HO has created a commercial forensic market it is difficult to see how it expects to control in-house self-funded research projects that are ultimately driven to gain market position and a leading edge in delivering services.

Roger Robson
Managing Director 11-3-2011

FORENSIC ISOTOPE RATIO MASS SPECTROMETRY (FIRMS) NETWORK

The Forensic Isotope Ratio Mass Spectrometry (FIRMS) Network welcomes the opportunity to contribute to the Home Office review of research and development in forensic science.

Summary

A policy to guide forensic science research should be formulated in agreement with all stakeholders. The policy should meet the needs of both law enforcement and justice. Chemical profiling should fall within the scope of the review.

Introduction

1 The Forensic Isotope Ratio Mass Spectrometry (FIRMS) Network is a not-for-profit company, limited by guarantee and registered in England. It is governed by a Steering Group with an international membership. Among the principal aims of the Network are; to promote the forensic application of isotope analysis, define and encourage best practice, and promote regulation. Its main activities are: regulating practitioners in the field of isotope forensics; planning, managing, delivering and reporting inter-laboratory collaborative exercises; and delivering international conferences for FIRMS members. FIRMS Network members are among the leading researchers in the field of isotope forensics and chemical profiling. More information about the FIRMS Network may be obtained from the web site www.forensic-isotopes.org

2 Among the members of the FIRMS Steering Group are government servants of the UK, Australia, Germany, France, Netherlands and the USA. It would be inappropriate for those members to be associated with this submission. Therefore, this submission only reflects the views of the Directors of the Company and members of the Steering Group who are UK based academics, all named below.

Dr James Carter: Director and Chair of the Steering Group of the FIRMS Network. Mass Spec Analytical Ltd
Dr Wolfram Meier-Augenstein: Director of the FIRMS Network. Scottish Crop Research Institute and University of Dundee
Sean Doyle: Director of Quality, FIRMS Network. Linked Forensic Consultants Ltd
Dr Niamh Nic-Daeid, Centre for Forensic Science, University of Strathclyde
Dr Jurian Hoogewerff, Centre for Forensic Provenancing, University of East Anglia

A research policy

3 In our experience it is recognised by some stakeholders, i.e. police, providers and academia, that research in forensic science in England and Wales lacks effective coordination and direction. For example, police forces sponsor numerous small research projects at local universities with little or no inter-force coordination. This potentially results in a waste of resources as wheels are perhaps reinvented and research of little value is funded.

4 The police/Home Office should not be given the final say in deciding policy or in directing forensic science research. Research policy and priorities should

be decided in consultation with all key stakeholders; police, HO, MoJ, providers, practitioners, academia, the legal profession, professional bodies (e.g. Royal Society of Chemistry and Forensic Science Society) and UK Research Councils. In addition, regional bodies such as the European Network of Forensic Science Institutes (ENFSI) should be consulted and relied on to provide a lead.

5 In relation to university based research, policy should be implemented by a Research Council. Provided research proposals comply with agreed policy the Research Council should be left to make funding decisions based on academic criteria.

6 Law enforcement agencies must have the scientific tools to help prevent crime and protect society. Courts also need to rely on science to ensure a fair trial and a true verdict. The outputs of forensic science must be of the highest quality. In many jurisdictions, including those of the UK, the overriding duty of the forensic scientist is to the Court. Avoiding miscarriages of justice and maintaining public confidence in the CJS should be among the principal aims of forensic science research policy.

<u>The areas of forensic research within the remit of the FIRMS Network should fall within the scope of the review</u>

7 Isotopic techniques are part of the general area of chemical profiling. In addition to isotope analysis profiling techniques include trace element analysis and mass spectrometric detection.

Links of forensic importance addressed by chemical profiling include those between;

- batches of illicit drugs,
- starting materials and improvised explosives,
- persons and a geographic location,
- persons and materials.

In addition to establishing links, chemical profiling might also assist in determining distribution patterns (in the case of drugs) and monitoring methods used for the improvised manufacture of illicit substances.

8 Research in this area would be directed towards: the development, optimisation, validation and harmonisation of classification and comparison methodologies, and the design and delivery of suitable databases and enquiry tools.

9 This is a complex area and apart from the chemical profiling of drugs for intelligence purposes the field remains poorly exploited. In the opinion of the FIRMS Steering Group members named above, insufficient research effort is focused on chemical profiling despite its considerable potential.

Issues within the Terms of Reference

The scale, scope and impact of research and development carried out by forensic science providers

10 Private sector (commercial) providers commit a proportion of turnover to research and development to improve customer services with the aim of adding value to existing products or developing new ones. Research will usually be directed at volume crime. The past and current role of these providers, of all sizes, in undertaking and fostering research should be recognised and not underestimated.
11 Public sector (state funded) providers have historically worked closely with universities across many levels (undergraduate to post doctoral) developing and evaluating novel technologies and methodologies e.g. micro fluidics and novel detection systems. The current financial situation may significantly limit the role of the public sector in forensic science research.

12 The results of research undertaken by public sector forensic science providers (including police providers) sometimes remain in-house and do not find their way into peer-reviewed journals.
The results of publicly funded forensic science research should be placed in the public domain and subjected to external peer-review.

The extent and the ways in which the latest advances are assessed and accessed

14 Forensic practitioners tend to be conservative; preferring to remain on familiar ground and relying on tried and tested technology and methodology. This attitude has an advantage; such a position is more likely to provide reliable scientific evidence for the benefit of the investigation and the Court.

15 In formulating forensic science research policy this conservative nature should be taken into account. Forensic scientists, particularly those who regularly give evidence in court, should be consulted when developing policy and prioritising research areas. A particular discipline may not need a new technique or technology but merely the strengthening of what is already in place, an improvement in quality.

16 The reluctance to consider novel technologies and techniques may have a negative impact on the quality of scientific evidence. Sometimes it is only when an existing weakness results in a miscarriage of justice are new ways of working considered.

17 Practitioners, particularly those with heavy case loadings, are often too busy to keep in touch with the latest developments. Measures need to be found that encourage links with academia and an awareness of research.

18 The user community needs to monitor academia as it develops novel concepts and technologies which may not be directly relevant but can be adapted to meet the needs of justice and law enforcement. Therefore, a mechanism needs to be in place to identify and exploit relevant ‘non-forensic science’ academic research.

The scale and scope of forensic science research in academia and links with practice

19 It is hard to arrive at an accurate figure for the amount spent on university based forensic science research undertaken in the UK. The Environmental and Physical Sciences Research Council (EPRSC) web site 'Grants on the Web' does not list forensic science as a subject or research topic.

20 Themes and programs such as 'Crime Prevention/Personal Security' and 'Crime prevention and detection technologies' have provided, and continue to provide, significant funds for research. However, these areas are more focused on prevention and protection rather than investigation and prosecution.

21 The term 'forensic science' should perhaps be limited to the use of scientific reasoning for the purpose of effectively recovering evidence from a crime scene, its analysis, and interpretation; areas where there is much evidence that insufficient research is being done. This is particularly so in relation to the forensic exploitation of the crime scene and the interpretation of scientific evidence.

22 A budget related to the value of the market should be agreed and that amount transferred to a UK Research Council for the sole purpose of funding medium to long term research in forensic science (with a narrow definition).

23 A UK Research Council should implement an agreed policy which includes high level criteria such as; the research must aim to improve the quality of scientific evidence and increase public confidence in justice.

24 Specific attention should be paid to the United Sates of America, National Academy of Sciences report 'Strengthening forensic science in the United States: a path forward' and responses to that report particularly the US 'Criminal Justice and Forensic Science Reform Act of 2011'.

The current and potential contribution of international research networks

25 The FIRMS Network considers that such networks already make a significant contribution to forensic science research and practice. The FIRMS Network has contributed significantly to the validation of methods and the promotion of good practice through its regulatory framework. The European Network of Forensic Science Institutes should be consulted and relied on to provide a lead in terms of identifying research needs and priorities in forensic science research.

In conclusion

- Chemical profiling should fall within the scope of the review
- A research policy, formulated and agreed by all stakeholders, is required

- In terms of university based research, the policy should be implemented by a Research Council
- In formulating a research policy the following should be given consideration
    - Commercial providers to fund short to medium term research focussed on volume crime and law enforcement
    - Universities to be funded to study medium to long term needs
    - Publicly funded research undertaken either by, or in collaboration with, providers to be published in peer-reviewed journals
    - Relevant non-forensic university research to be identified and exploited
    - The conservative nature of forensic practice to be recognised
    - Avoiding miscarriages of justice and maintaining public confidence in the CJS to be high among the policy objectives
- The lack of research directed at the exploitation of the crime scene and the interpretation of scientific evidence should be addressed
- Forensic science should be more narrowly defined.

FORENSIC SCIENCE NORTHERN IRELAND

Dear Prof Silverman

Thank you for invitation to contribute to the review of R&D in Forensic Science. I apologise for the slight lateness of my response.

I respond as Chief Executive of Forensic Science Northern Ireland, which is as you know an Executive Agency of the Department of Justice within the devolved Northern Ireland administration (www.fsni.gov.uk) and as a member of the FSAC. FSNI have a broader range of forensic disciplines than most other providers and for us the integration of multiple evidence streams is a key factor.

Please find below, our response to your questions. If you require any further discussion on any issue, we would be happy to oblige.

Yours sincerely

Stan Brown
Chief Executive

Questions for forensic science providers

The scale, scope and impact of the research and development carried out by forensic science providers and related organisations (in the public and private sector).

1. Scale of R & D: e.g.

    a. Research budget;

    - Our annual expenditure on R&D is ca £200k (which represents just under 2% of our total running costs, but this activity is mostly funded directly out of our normal resource budgets.

    b. Capital investment in R & D;

    - Very little is dedicated specifically to R&D. Most capital investment would be method improvements and the purchase of new instrumentation. In relation to the development of enhanced DNA methods (using the next generation kits) we intend to invest £12m in a new state of the art evidence recovery and DNA facility, but this is more related to business development than to R&D *per se*.

    c. Size of research workforce;

    - We currently have 0.5 of a person actually dedicated to a specific R&D project to the exclusion of all else. In addition, one Principal Scientific Officer dedicates approx 20% of their time to Research liaison with Universities. The remainder of resource targeted at R&D is mostly related to Development rather than Research, via a proportion of operational scientists' time, as hands-on knowledge of the forensic applications is best done, we believe in the practitioner context. (We have incidentally approx 160 scientific staff out of a total complement of 220 total).

    d. Details of dedicated facilities;

    - None of our facilities are dedicated specifically to R&D, i.e. to the exclusion of casework.

2. Scope: e.g. topics of recent and current interest in your own organisation's research

    - DNA Next Generation PCR Kits (in common with other providers across Europe).
    - DNA Robotics

    - Raman Spectroscopy of Paints, Inks, Drugs
    - Peroxide Explosives identification using Raman
    - Computer Forensics, Cell Site Analysis and Chip extraction
    - Latent Fingerprints: Functionalised Nanoparticles for Visualisation

- Infrared imagery for blood pattern visualisation on patterned or dark background materials
- In-field Chemical profiling of Improvised Explosives
- Characterisation of “Legal Highs” using Nuclear Magnetic Resonance and High Resolution Mass Spectroscopy
- Antigen fluorescence of Sperm heads using UV Microscopy
- Surface Enhanced Raman Spectroscopy of Organic Explosives
- 3D laser scanning of Road Traffic Collision scenes

3. Suggestion of any areas where you feel more research would be useful.

- Automated initial rapid screening of exhibits for glass, paint, fibres, body fluids, etc. during primary evidence recovery. This would greatly speed up the early stages of evidence recovery, boost productivity and allow more exhibits to be screened economically.
- In-field Presumptive Testing for drugs of abuse in bulk and in body fluids
- Characterisation of newly developed synthetic drugs of abuse
- Software support packages for improved DNA profile (mixed, partial and familial) analysis
- Rapid confirmatory techniques for drugs, (prescribed and of abuse)
- Real Time monitoring of contamination levels DNA, Explosives, Drugs and other trace residues, e.g. through bioluminescence or other rapid methods, allowing faster return to production readiness and more robust evidential findings
- Lab-on-a-chip technology in general (bringing FS more into real-time in-field applications)
- Rapid Interrogation tools for computer forensics/mobile phones
- Improved evidential databases to support Bayesian and other analysis of likelihood ratios (fibres, footwear, trace evidence)

4. Impact: e.g. examples where your research has had impact, or will have obvious impact, on forensic science provision and practice.

- Next Generation DNA PCR will replace Low Template methods, increase supply choice, and make profile analysis more evidentially robust.
- Use of portable tuneable lasers for in-field visualisation of latent marks and prints has increased scene recovery rates by ca 30%
- FSNI are leaders in integration of forensic recovery techniques, e.g. DNA, prints, fibres and data from Mobile phones, etc.
- Raman Spectroscopy used for non-destructive testing of drugs and explosives and other trace evidence types
- Combined recovery and analysis of organic and inorganic Explosives and Firearms (Cartridge) Discharge residues
- First UK lab with integrated control protocols for multiple contaminant types, including zoning, etc.

- Characterisation of synthetic drugs of abuse
- Special Fingerprint Unit UK leaders, along with met in multistage enhanced techniques for latent print visualisation
- In-lab Chip Extraction of Mobile Phones and Hexadecimal analysis of mobile phones' flash drives have both driven substantial increases in data recovery versus Plug and Play software/hardware

5. Partnerships: to include details of research and development in the UK and abroad.

- Queens University Belfast (QUB), Department of Molecular Materials: Collaboration on the forensic use of nanotechnology, Raman Spectroscopy, characterisation of synthetic drugs of abuse, Explosives test kits.
- Cork University: EU 7 Framework "Steadfast" research programme on in-filed analysis of explosives using nanotechnology.
- Through QUB, collaboration with the US FBI on multilayer white paint analysis

6. Funding: to include details of externally funded projects, source of funds, project scope, time scales and progress.

- See Steadfast Programme above re EU 7. 2 year programme with consultancy input from FSNI

7. The extent, and the ways in which, forensic science practice assesses the relevance of, and accesses, the latest advances in technologies and techniques.

   Regular interaction with other providers through working groups of the Association of Forensic Science Providers (AFSP), ENFSI, other international bodies and local Universities

8. How do you bring current scientific developments into practice?

   a. Please explain any mechanisms and/or give examples.

- Product management protocol taking ideas from Need Identification, market Appraisal, through Feasibility, Technical Development, Trialling, Validation, Accreditation, Launch, Performance Review. Process mediated between Business Development Directorate and Operations Directorates

   b. Are there any barriers to this process?

- UKAS processes, Internal Resources, Funding, Procurement Regulations

9. The scale and scope of forensic science research undertaken in academia and its links with forensic science practice.

a. What links, if any, do you have with academia, and what value do you place on these?

- See earlier. FSNI work closely with Queens University Belfast on a range of activities. Our specialist fingerprint Unit (SFU) also work with Manchester University

b. Please also comment on the value of academic work to your business, whether or not it is part of a specific or explicit link.

- In order to offset resource constraints within FSNI, we rely on externally funded R&D through universities, with FSNI supplying the forensic application knowhow.

10. The current and potential contribution of international research networks to UK forensic science research and practice.

- The European Network of Forensic Science Institutes (ENFSI) of which FSNI is one of the >50 member organisations, facilitates collaboration across a broad range of forensic disciplines. The Association of Forensic Science Providers (AFSP) of UK and Ireland, facilitates work on body fluids, trials, etc.

11. Please give any specific examples or comments.

- Exchange of information across ENFSI is open and normally at no charge, (e.g. paints, fibres, e-forensics, etc.) but commercialisation of UK providers may inhibit open sharing of IPR, as almost all ENFSI members do not approve of commercialisation of FS.

Any other comments

Forensic science is for the most part the development of the application of scientific and technological advances arising elsewhere into the forensic arena. This legal framework imposes requirements onto the science, of robustness and transparency, such that the protection of confidential know-how may not be compatible with the court's requirement for confidence concerning the reliability of the scientific methods used and their underpinnings.
The two distinct aspects of forensic science which it us useful to treat differently in R&D terms are

Source: i.e. The detection, recovery, identification, comparison, quantification of materials and substances, often at very low levels, from exhibits. R&D in this area is best focussed on new, faster, more sensitive or more discriminating methods. Relies to some degree on innovation by instrument manufacturers and overspill from other walks of science/technology

Activity: The evaluation by Reporting officers of the scenarios proposed to explain the evidence, based on experience, databases and Bayesian probabilities/likelihood ratios. It is important here to research factors that may give rise to spurious evaluations and to underpin assessments of probabilities. Examples would include modes of secondary, tertiary transfer of DNA, etc.

There needs to be centrally funded R&D resources made available to avoid duplication between the UK's labs. The issue of sharing IPR must be addressed to ensure best practice is evenly spread across the country and available to all forces and courts.

NPIA should not be the focus for this coordination, as they are a police-focussed, rather than criminal justice focussed. This function could be one for the FSAC or a subgroup, with NPIA, ACPO's important input regarding police customer need, as defined in outcome rather than solution. A police - or NPIA-centric approach ignores the importance of a science-led technology push, rather than the customer-pull aspects of R&D, which will be limited by customers' own imagination and awareness. NPIA will also not be able to directly influence the adoption of best practice across Europe and further afield (including through ENFSI), on which all providers rely as members of a wider scientific community and on which the courts themselves rely.

Science is best done through scientific organisations with practical and contextual knowhow working collaboratively with more "pure" research functions of Universities.

FORENSIC SCIENCE SERVICE 1

This submission has been written by and on behalf of the Senior Scientists currently employed in the Research and Development group of the Forensic Science Service (FSS).

The views expressed within this submission are those of the researchers and do not necessarily reflect those of the Forensic Science Service.

1. What work relevant to forensic science is being done in your group/university and what are the opportunities for the future?

1.1 The research group comprises professional career research scientists with a wide scope of expertise and many years experience in delivering innovative solutions to the forensic field.

Our multidiscipline team of molecular biologists, chemists, electronics experts, statisticians, software developers and engineers is perhaps unique in the world. Our strength is not in the discovery of new techniques *per se*, rather in the assessment, adoption and adaptation of available technologies to develop robust, court-ready processes. Together with our casework colleagues, we have demonstrated capability to understand problems and define viable solutions. The implications of new data types and formation novel processes and systems are thoroughly tested and validated to be robust for presentation in the UK courts of law.

1.2 Current projects include:
(a) Collaboration, design and implementation of new DNA multiplexes compliant with new European legislation, [1,2]
(b) Development of faSTR technology – to deliver new 16-loci STR profiles within 2 hours,[3]
(c) Development of probabilistic fingerprint assessment, and its implementation in FSS FINGERPRINT DACTSYS
(d) Development and implementation of FSS DNA LINEAGE for kinship analysis, award winning DNA INSIGHT software for DNA interpretation [4] and FSS-iD a validated DNA database solution [5]
(e) Data management systems that can identify complex association networks from mobile phone data and present interactive onscreen results, saving customers days of analysis,
(f) Implementation of a method to assign likelihood ratios to complex DNA profiles enabling the assignation of an evidential weight to complex DNA profiles, benefiting the UK courts.
1.3 Future projects;
a) Validation of 16-loci multiplexes for the application to Low Template DNA samples,
b) Expansion of evidence association networks to other evidence types,
c) faSTR DNA for crimestain samples: evidential quality DNA in <2 hours,
d) Three person DNA mixture convolution and reporting within a continuous likelihood ratio approach, e) Disaster Victim Identification database,
The completion of many current and future undertakings is unlikely before the planned
closure of the FSS.

2. What previous and current research partnerships do you have with forensic science providers, police forces, the National Policing Improvement Agency, etc.?

2.1 Previous research collaborations include;

a) Involvement in a number of academic projects funded by the RCUK. [6]

b) Investigation into the application of microfluidics for DNA analysis with NetBio, IntegenX, Micro Fluidic Systems Inc., QinetiQ, Arizona State University, and Dolomite

c) Developmental and or evaluation projects with life science corporations including Qiagen, Applied Biosystems and Promega Corp.

d) DNAboost service for the National Police Improvement Agency (NPIA) identifying individuals from previously interpretable and complex (more than three) person mixtures

2.2 Examples of current research partnerships:

a) FSS R&D are lead partners in a project to develop fast DNA profiling (Section 5), [7]

b) Partners on 3 EPSRC CASE awards

A summary of research partnerships and professional relationships is available. [8]

3. Can you give good examples in the forensic science field of translation of research into practice, and also any examples where this has been difficult or problematic?

3.1 A lack of understanding of the real problems and issues for a forensic practitioner means that solutions are rarely adequate for the courts. For example, a well respected group of academic statisticians [9], have published models in peer reviewed journals, however no forensic organisations have implemented these methods.

The successful introduction of novel statistical models to forensic practice requires practising statisticians that have

– access to real data,

– expertise to understand the intricacies of the area,

– training to understand the complexities of statistical research and make academic research fit-for-purpose.

The FSS R&D statisticians have developed and validated a model for de-convolving DNA mixed profiles based on academic research. This model has been implemented into the FSS, providing consistency, robustness, and cost effectiveness for the taxpayer.

3.2 Using database techniques, data-mining algorithms and web technologies, the electronic forensic team created a new reporting method that presents phone data (around 250 pages of text data) pictorially in an interactive web page. This technique was trialled with the UK Borders Agency and considerably assisted the interpretation of the case data.

3.3 The implementation of innovative processes into the national DNA database has proven more difficult since control of the database was transferred to the NPIA. For example, whilst the FSS and other FSPs are

ready to implement new multiplexes into standard process, the NDNAD is still unable to accept these profiles, and is unlikely be in a position to do so before the EU legislated, 30th November 2011, deadline.

3.4 Introduced world-leading high throughput automation to routine DNA testing in the UK and internationally. This has increased capacity and reduced cost.

4. What do you see as the opportunities for, and the barriers to, the funding of research relevant to forensic science?

4.1 There are few calls specifically for forensic/crime initiatives from the RCUK. Previous calls include the Think Crime program from EPSRC. Over £10 million has been made available for the development of future forensic capability by EPSRC.[10] Such funding typically allows for the investigation of the basic science needed to underpin a new technique. Once this is complete, complementary research to bring fit-for-purpose solutions, device or process design, robustness testing, and field testing is needed and funding for such R&D activities is scarce and inadequate. This provides a major barrier to the adoption of academic research. There may be a misguided belief that academic research, on its own, can bring innovation into practice. The gap between academic success and forensic robustness is sizeable.

4.2 We have been successful in securing FP7 funding from the EU (see below)

5. What are the important international networks and how useful are they? Do you haveany specific international collaborations you would wish to draw to our attention?

The European Network of Forensic Science Institutes (ENFSI) is a platform for sharing information between European forensic laboratories. For example, the highly active ENFSI DNA working group strives to ensure best practice is followed throughout Europe. Working with ENFSI has allowed FSS to remain involved in critical research areas to which we would have otherwise been unable to contribute due to commercial pressures (e.g. the use of mRNA for cell type identification). FSS R&D also helps drive quality at the European level through representation on ENFSI QCC and leading on EU funded projects.[11, 12] FSS R&D is currently the lead partner in a European FP7 project with 3 of the leading forensic laboratories in Europe, a UK SME and a US University to develop a crime-stain system for DNA analysis in under 2 hours.[7]

6. Are there any other issues relevant to our terms of reference that you would wish to comment on?

The capability of the R&D team in the FSS is world class. Exposure to real world applications has refined the scientific skills and methodologies required to provide dedicated, world class forensic research. Dissolution of the team, given their experience and cumulative expertise would be detrimental to the future of forensic research in the UK. Acquiring such expertise takes years; building a new team would require a significant investment by the taxpayer and a significant knowledge gap.

Rather, we would support the development of a properly funded national centre to host research and training facilities, hold reference data and provide a quality assurance services for all UK forensic laboratories. Such a centre may also include responsibility for national forensic databases, provision of niche capabilities, a major incidents capacity, and provide international consultancy on behalf of the UK.

The cost of forensic research to bring innovation into practice is small in comparison to the funding available for general academic research. In 2009-2010 FSS R&D cost c. £4 million to successfully operate [13]. This cost might be supplemented through research grants and by providing services to FSPs in the UK and internationally, and delivery of niche casework.

Dr Andrew Hopwood; Senior Research Scientist
Dr Jacob Irwin; Science Manager – Physical Sciences
Mr Richard Livett; Science Manager – Software Development
Mr John Proudlock; Science Manager – Digital Forensics
Dr Roberto Puch-Solis; Senior Research Statistician
Ms Diane Rowlands; Science Manager – Scientific Support
Dr Jon Wetton; Senior Research Scientist

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on-line
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entID=8 (accessed 18.03.2011)
[5] *FSS (2008) FSS-iD DNA database available online*
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18.03.2011)
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[7] http://www.forensic.gov.uk/html/company/partnership/
[8] http://www.forensic.gov.uk/html/company/research-innovation/collaborations/

[9] Dr Robert Cowell of City University, Stephen Lauritzen of Oxford University, Julia Mortera
of Roma Tree University
[10]
http://www.epsrc.ac.uk/newsevents/casestudies/forensics/Pages/default.aspx
[11] http://www.enfsi.eu/page.php?uid=86
[12] http://www.enfsi.eu/page.php?uid=179
[13] http://www.forensic.gov.uk/userfiles/FSS%20Annual%20Report%202009-10.pdf

FORENSIC SCIENCE SERVICE 2

Forensic Science Research & Development: Submission from FSS

We believe that preservation of skills in a dedicated R&D facility, closely associated with practitioners and collaborating with academia, industry and CJS stakeholders is the optimal way to safeguard innovation in Forensic Science for the future.

1.1 Scale

	12/05-03/07*	04/07 - 03/08	04/08 – 03/09	04/09 – 03/10	04/10 – 03/11
Running Costs £k	5,889	3,530	4,014	4,112	3,500
Capital Investment £k	287	7	1,385	1,450	87
No. of dedicated R&D staff[1]	87	68	61	59	60
External funding £k	539	184	283	424	953

Table 1: FSS R&D Scale & Funding summary

* extended period following GovCo vesting 12/05

In the 5 full years prior to vesting (Apr 00 – Mar 05), FSS R&D running costs were (respectively, £k): 3,173, 3,670, 3,471, 2,623, 3,952.

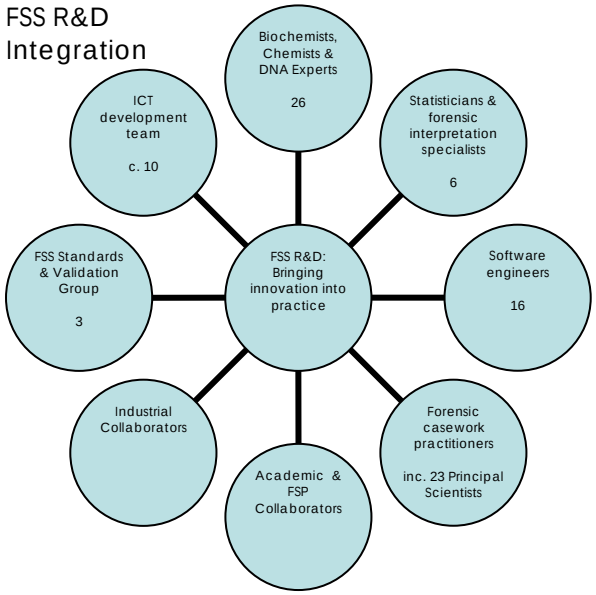
Dedicated R&D facilities (c.800m^2) include:

- Fully equipped DNA laboratories
- Secured laboratories for classified R&D & controlled drug collection
- Electronics facilities for e-forensic R&D
- Dedicated network for software development.

FSS ICT department and operational laboratories contribute to R&D, additional to table 1.

Integration of dedicated facilities and people with the wider forensic community (practitioners, quality group, academics, industry) is key to FSS innovation[2].

[2] Summary of current FSS collaborations at http://www.forensic.gov.uk/html/company/research-innovation/collaborations/



1.2 Scope

Appendix 1 illustrates FSS R&D roadmap. Long term, we envisage de-skilled, integrated, real-time analysis, with an increase in tools and data to enhance and automate interpretation for intelligence and evidential purposes.

Recent achievements include:

- Development, validation and implementation of new automated DNA processing facilities and interpretation software, increasing quality and efficiency.
- Development of a probabilistic method for evaluating fingerprint evidence (Dactsys), which provides a robust, transparent means of reporting fingerprint matches.
- Demonstrating cost and time savings in police investigations through using interactive graphical frameworks.
- Development of an electronic casefile system deployed across multiple sites and c.660 users.
- Development of rapid DNA system for reference samples to point of transfer to a commercialisation partner.

Current/future priorities:

- Further model and software development for probabilistic analysis of low template multi-contributor DNA: to improve quality and efficiency, and increase the proportion of samples providing intelligence and evidence.
- Providing probabilistic network tools and structured data sets to enable forensic practitioners to interpret evidence through scenario evaluation.
- Expansion of graphical framework to multiple evidence types, and the presentation of complex evidence in court.

- Development of rapid DNA system for casework samples[3].

1.3 Impact

We conduct applied research: our aim is to identify scientific advances (primarily from academia and industry), develop to meet forensic requirements, validate and implement for intelligence or court use. We have implemented c.120 new or significantly improved methods since 2005. Publications are a by-product of this research rather than an end in themselves, so direct comparison against academic publication rates does not adequately reflect FSS research productivity. Nevertheless, FSS staff have been amongst the most prolific publishers in the field, with c.200 papers since 2000[4]; these papers have been cited 3660 times. FSS holds c. 50 patent families. The most obvious example FSS research impact is DNA, from its inception to the future deployment of DNA profiling devices in custody suites (Appendix 2).

FSS innovation is widely considered to have had world-wide impact[5]. We have conducted casework using novel techniques in many jurisdictions[6] and our innovations have led to resolution of numerous cold cases[7]. We play a leading role in professional bodies with international reach[8].
Dactsys is likely to have a major impact, particularly in the light of the NAS Report[9].

1.4 Partnerships

A summary of FSS collaboration with academics, forensic institutes and industry is provided[10].
In evidence to the Science & Technology Select Committee[11], Cellmark remarked that FSS did not invent DNA profiling, PCR, STR analysis, or fluorescent fragment analysis. This is correct and illustrates the role of partnerships in FSS R&D. FSS worked with Professor Sir Alec Jeffreys to bring his invention into forensic practice, developed robust PCR-based methods from early published work and collaborated with industry to develop robust protocols, validate and implement STR multiplexes such as SGMplus™ and use of fluorescent fragment analysis instruments for forensic analysis, publishing joint papers with our collaborators through the peer review process. Without a substantial dedicated R&D function closely associated with operational forensic scientists, it is difficult to envisage how these advances would have been brought into practice.

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[3] As lead of consortium, part-funded by Framework7:
http://www.forensic.gov.uk/html/company/partnership/
[4] http://www.forensic.gov.uk/html/company/research-innovation/skills-experience/
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[10] http://www.forensic.gov.uk/html/company/research-innovation/collaborations/
[11] http://www.publications.parliament.uk/pa/cm201011/cmselect/cmsctech/writev/forensic/m73.htm

1.5 Funding

Since vesting as a GovCo in 2005, no new research funding has been granted to FSS from the Home Office. R&D is primarily internally funded, with some external funding won on a competitive basis (Table 1). The largest externally funded project is development of FSS rapid DNA technology for casework samples. Further information on this project is available[12]; it is a partnership including 3 further leading European forensic institutes, a leading US academic group and a UK SME. The 3-year project commenced in 2010, and is on track against milestones.

2. Accessing latest advances

Active horizon scanning from literature and patents, conferences and via collaborators enables identification of potentially valuable technologies. Initial evaluation, either internal or collaborative, may lead to initiation of formal research. An example at the evaluation phase is next generation sequencing, on which we are collaborating with a government laboratory.

Once research has demonstrated that a technique is suited to forensic practice, implementation is considered.
For internal implementation, the procedure is straightforward and sole barriers are resource (e.g. equipment purchase and/or abstraction of operational scientists for training) and timing (availability of UKAS/NAS for accreditation). Validation is performed, and UKAS accreditation sought. Where a new technique fits within processes leading to NDNAD loading, accreditation by NAS is obtained prior to implementation.

However, if a development requires changes to the NDNAD or impacts on Policing or Courts, barriers are greater. Probabilistic interpretation of fingerprints was identified as a challenge in the Home Office Science and Innovation Strategy 2009-2012. FSS developed a solution to this challenge and presented it to ACPO Technology and Innovation Group (01/09). This was well received and led to involvement of the fingerprint Expert Network. Despite this innovation having the potential to improve the quality of evidence presented in courts, progress stalled. Forensic science is procured by Police, but the courts are the ultimate customer: relying solely on commercially viable research in forensic science is likely to inhibit innovation of value to courts.

Notwithstanding the plan for Science and Innovation in the Police Service[13], there is insufficient open and constructive dialogue between Police, Courts and researchers (whether in FSPs, academia or industry). NPIA's coordinating role can reduce direct communication with Police Forces; FSS interaction with Scottish and Northern Irish FSPs and Police Forces has proved simpler.

3. Academia

[12] http://www.forensic.gov.uk/html/company/partnership/
[13] http://www.npia.police.uk/en/docs/science_and_innovation.pdf

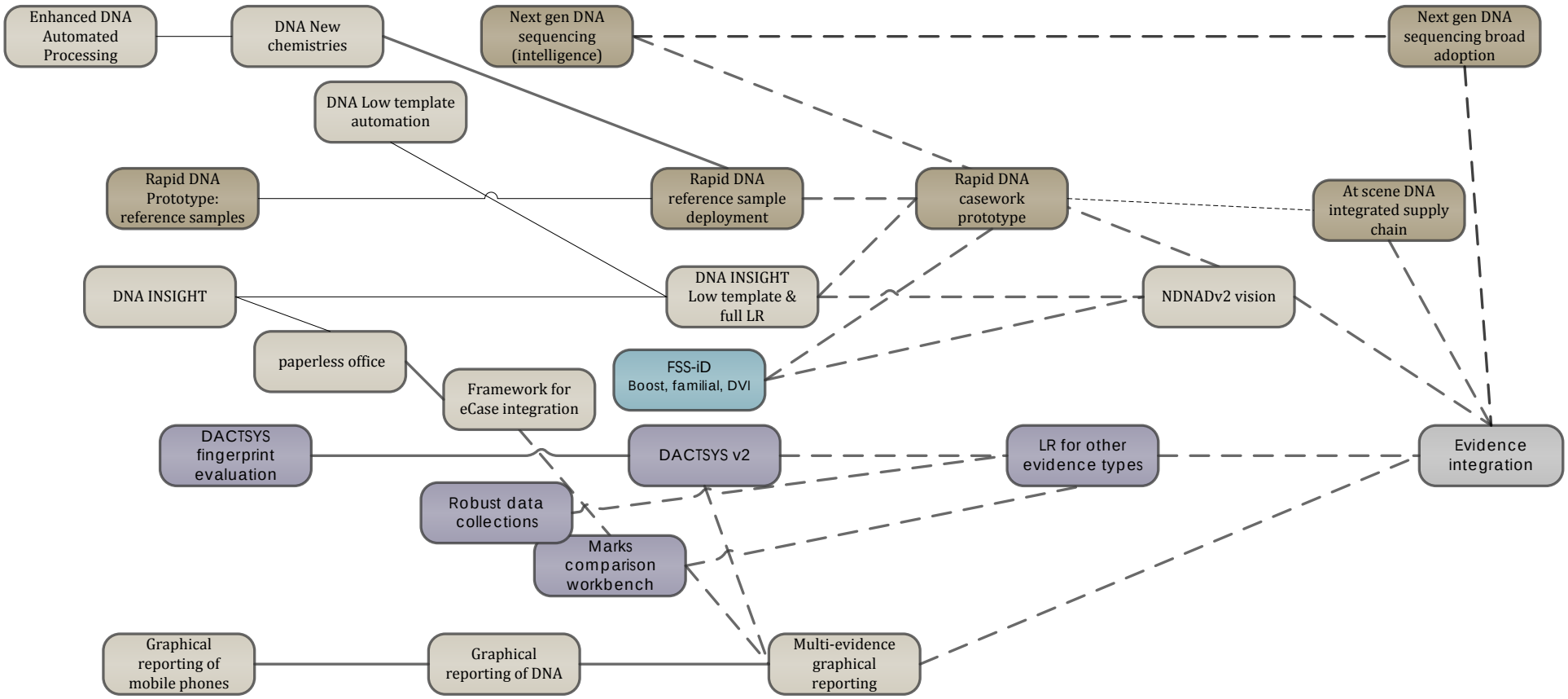
A summary of FSS links with academia is provided[14]. We support academia by training students during BSc, MSc and PhDs and benefit from novel science, e.g. microfluidics expertise from University of Arizona. FSS collaborations with academic Forensic Science groups are fewer than those with leading academic groups in wider scientific fields (wherever their location), better complementing our internal skills.

4. International Networks

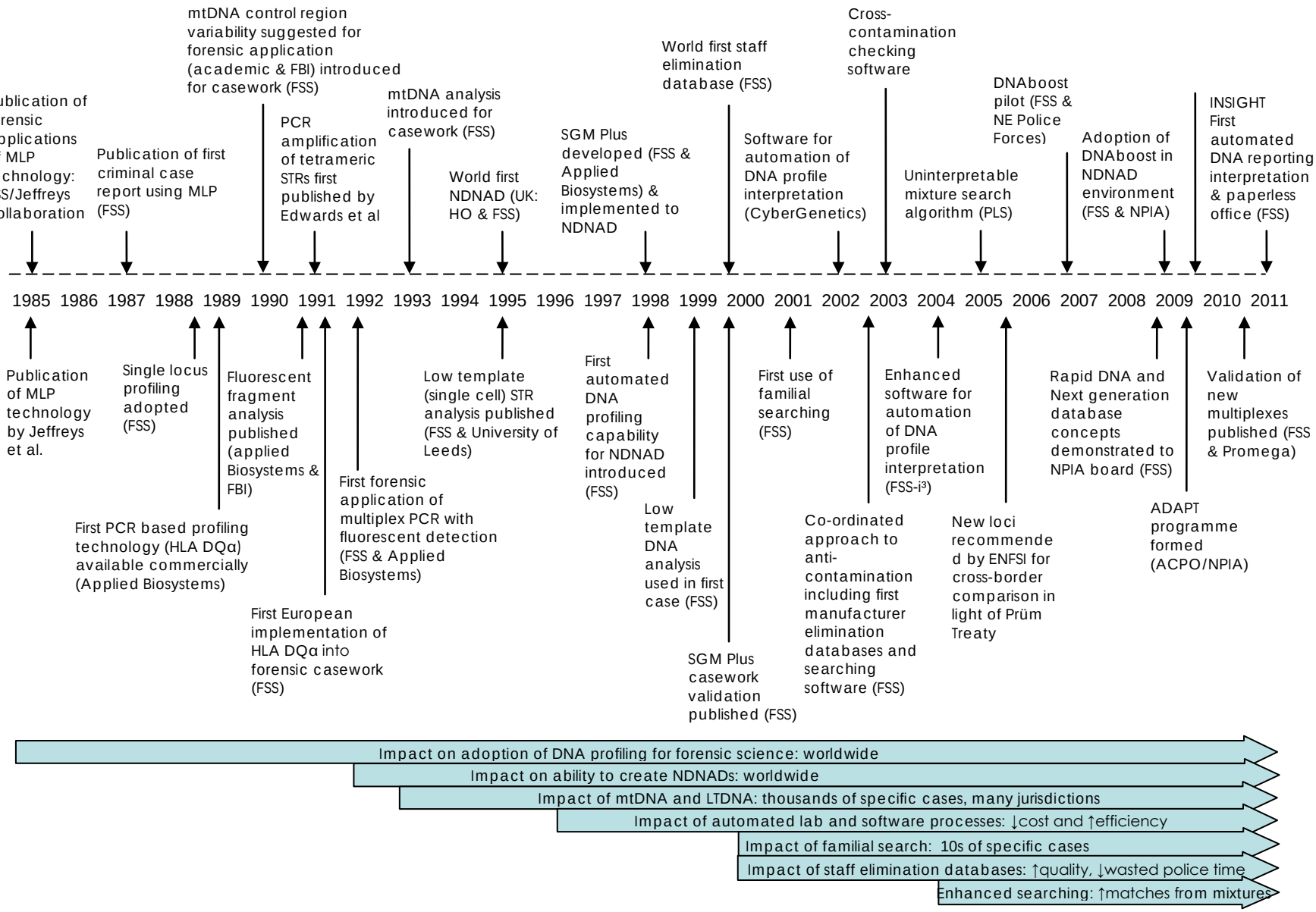
The FP7 research consortium is discussed above. FSS plays a leading role in collaborative research in the EDNAP group[15] and Body Fluid Forum; large volumes of data are generated through such networks by spreading work amongst laboratories. The coordination burden is significant, so ongoing support by laboratories with dedicated researchers is important. ENFSI[16] is an invaluable international network, but is less involved in research than in standards and quality; its role in promoting validation standards through the Quality and Competence Committee is vital and actively supported by FSS.

[14] http://www.forensic.gov.uk/html/company/research-innovation/collaborations/
[15] http://www.isfg.org/EDNAP (European DNA Profiling Group)
[16] http://www.enfsi.eu/index.php

Appendix 1: Innovation Roadmap



Appendix 2: Example of FSS Innovation Impact (DNA)



FORENSIC SCIENCE SOCIETY

The Forensic Science Society is the professional body for forensic practitioners and has among its membership representatives from private and government institutions, academia, and the legal fraternity. It is an international organisation with members from over sixty countries. The role of the Society is to promote quality standards in all branches of forensic science including educational provision.

This submission is made by the Society following consultation with its Fellows together with fourteen of its accredited universities. The précis represents their collective views as well as those from members of other government establishments and private sector organisations who were present during a meeting of the Society's Education-Industry Liaison Forum.

The scale, scope and impact of the research and development carried out by forensic science providers and related organisations (in the public and private sector).

- Although historically the government laboratories have been major contributors currently there appears to be little research **of impact** being carried out by providers. However, given that most providers are now commercial companies their research is not likely to be known until it becomes commercially available.

- The biggest benefit of R□&D at the "field" level of forensic practice is its direct translation to casework and therefore any future developments should take into account the need to improve understanding in relation to evidence-based practice.

The extent, and the ways in which, forensic science practice assesses the relevance of, and accesses, the latest advances in technologies and techniques.

- The scientist working in the laboratory of today is not well placed to recognise and exploit emerging technologies because of a more process approach to casework. Police may be in a better position but need a particular approach to devote time to checking out emerging technology. The equipment companies are anxious to exploit the potential market and though are putting resources into research are obviously only interested in high demand areas.

The scale and scope of forensic science research undertaken in academia and its links with the forensic science practice.

In order to maximise the capability and resources within the many and varied establishments it was unanimously agreed that there should be much greater collaboration between the universities, police / NPIA and the providers.
From a police perspective this could be achieved by:

- police forces communicating their particular (long term) needs more effectively;
- identification of past problem areas within casework not yet addressed;
- identification of perceived gaps between needs and provision;
- greater use of experienced researchers to circumvent the legal difficulties of using students.

From a university perspective there was a requirement for:

- a two way exchange of personnel in the form of research based placements;
- accessible list of expertise and research projects being undertaken across academia;
- a mechanism to ensure fast and efficient costing and approval of applications by higher education institutions allied with project time scales;
- a recognition of forensic science for independent funding by research councils;
- funding for institutions with a sound teaching background as well as for institutions with research credentials.

From the providers perspective it was felt that

- funding accessibility needs to improve for the non-mainstream disciplines. It is possible that these areas will in time also become mainstream, thereby strengthening forensic science through the availability of more cost effective and evidence-based techniques. The inclusion of specialist areas in the review is therefore important.

The current and potential contribution of international research networks to UK forensic science research and practice.

- International research networks need to be strengthened. The need to improve R&D in forensic practice is currently being recognised in other countries (e.g. US) and therefore there is the potential to share knowledge, programmes and experiences.

General Recommendation

In conclusion it was proposed that a strategy should be formulated which would address the needs and support future developments through appropriate funding, collaborative working and sharing of resources.

This should be co-ordinated by an appropriate body which could act as a portal to facilitate interaction between all parties.

FORENSIC TELECOMMUNICATION SERVICES

1. The scale, scope and impact of the research and development carried out for forensic science providers and related organisations (in the public and private sector)

The R&D department at FTS consists of a team of highly qualified and experienced hardware and software engineers with world leading expertise in the area of mobile devices and technology, with particular emphasis on forensic examination, data extraction and analysis techniques.
The team currently consists of 5 engineers (out of a total workforce of approximately 40). Research budget is £222,500.00 . R&D capital expenditure £40,000.00.

The department provides a vital technical support function to engineers in FTS's forensic laboratories, providing tools, advice and training on the latest technology and analysis techniques. One area of particular importance is the validation of new software and techniques, a function that is instrumental in obtaining and maintaining FTS's ISO 17025 accreditation.

In addition engineers in the R&D department regularly perform examination and/or analysis of devices where this requires their specialist expertise and tools. This may for example be for devices not supported in standard extraction and analysis tools, novel or unusual devices (e.g. satellite phones, taxi meters etc), PDAs and GPS units or badly damaged devices.
The department is continuously developing new software and techniques in the areas of forensic examination of mobile devices, for use both within FTS and as products to provide to external customers. Products developed and supported within the department include:

M-Filter (FTS Hex): an advance suite for the extraction and forensic analysis of data (including deleted data) from mobile phones.
iXam: a world leading solution for the extraction and forensic analysis of data from iPhones, iTouch and iPad devices.
SIMiFor: a complete solution for SIM card reading and cloning, specifically designed for forensic use.

These services and products are vital to allowing FTS to maintain a comprehensive service to our customers in a rapidly changing technical sector. The research and resultant capability has a high and immediate impact on Forensic Science provision.

Our customers from law enforcement agencies look to us to provide forensically sound solutions to devices and technologies almost as soon as these are released and are in use. A good example of the impact of research is in the analysis of Blackberry devices, where in certain situations, our

advanced capabilities offer one of the only solutions available for law enforcement agencies to obtain evidential material

from seized devices.
Research funding is derived from a mixture of internal and external sources. External funding generally comes via two mechanisms:

1. If FTS do not have the immediate capability to do a standard extraction and analysis of a particular device, a customer may pay for specific research and development time to develop a solution for this specific exhibit. The cost in this case would usually involve the purchase of a test device, possibly dedicated test hardware and the analysis time of an R&D engineer. In this case the project timescales are usually short (of the order of a few weeks). Costs may be wholly charged to the customer, or if support the device is likely to be of future interest to FTS, partially funded internally.

2. Customers (including government agencies) also fund projects to develop specific capabilities either as enhancements to our existing product or as new products. An example of such a project may be to develop analysis capabilities for a class of Satellite Phones. These projects will be longer term, generally 6 months plus.

Generally R&D development is undertaken internally. Occasionally some development has been outsourced to external parties (including academic institutions) on a contract basis. FTS has also developed specific products in partnership with other private UK companies to create specific solutions for the security market

2. The extent and ways in which forensic science practice assesses the relevance of, and accesses, the latest advances in technologies and techniques.
R&D within FTS is very focussed on customer requirements and is driven by the technology and devices that customers are looking to us to support. Development is governed by forensic principles, and the requirement that all products and services developed will ultimately need to be validated for use within the ISO 17025 framework in place within the company laboratory.

A major barrier to the development is lack of support from the device manufacturers. Manufacturers are very reluctant to provide technical details to us that would facilitate the development of forensic solutions for their devices. This greatly increases the time and effort involved in developing these solutions.

3. The scale and scope of forensic science research undertaken in academia
and its links with forensic science practice.
For R&D activities FTS does not have any link with academia. FTS has not as yet identified any areas of academic research that are immediately of value to our business. In our exp long term and “blue sky” research projects than those that we are focussed on. In our experience involving academia can be also be a bureaucratic and time consuming process.

4. The current and potential contribution of international research networks to
UK forensic science research and practice.
In many respects the same comments as for academia (Q3) apply. FTS has not to date derived any particularly useful input from international research networks. We have investigated getting involved in some programmes (eg FP7 Security Theme) however again found the topics to be more long term focussed with very little practical pull through to products and the process very bureaucratic.

General Comment
As a forensic service provider within digital forensics there is no requirement to retain our own R + D function. We could just use off the shelf software such as encase, Xry and Cellebrite etc. However the advances in digital devices and technology available globally will always require innovative research teams to create solutions to ensure Law Enforcement agencies can extract from even the most advanced devices. The main inhibitor facing our type of forensics is that in the UK the drive to provide the digital forensic service is to going to in-house units to 'save costs or jobs' By doing this they limit the amount of submissions to private forensic service providers which in itself limits the amount put towards R+D. A Public Sector Law Enforcement agency could not justify having R + D dedicated staff to fill this gap, therefore it relies on the private sector to invest in it.

Providing a forensic service and innovative research and development are not mutually exclusive, indeed one benefits from the other, however the withdrawal of Law Enforcement outsourcing and the blindness to see this is stifling private sector innovation, enterprise and indeed growth.

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w w w . F o r e n s i c T S . c o . u k

THE FORENSIC WORKING GROUP FOR THE PARTNERSHIP AGAINST WILDLIFE CRIME.

The Forensic Working Group aims to investigate, examine, analyse and document current issues relevant to the practical application of technologies that can be used to assist in the fight against wildlife crime. The Working Group will advise those dealing with wildlife crime on forensic matters and communicate updates as appropriate.

The Working Group is composed of representatives of the Police, National Wildlife Crime Unit, Animal Health, DEFRA, UKBA, HMRC, RSPB, RSPCA, TRAFFIC, Veterinary Surgeons, Kew Gardens and forensic laboratories including FERA, SASA, FSS.

Since its inception, the FWG has carried out numerous research projects in this field. These research projects include:-

- Forensic DNA profiling for raptor protection: a two and a half year project funded by Defra and undertaken by WDNAS to develop microsatellite-based DNA profiling systems for the individual identification of golden eagles, goshawks, merlins, peregrine falcons, gyr falcons and sake falcons. The results will be used to allow family relationships between birds to be verified based on genetic analysis of moulted feathers.
- Forensic DNA profiling for badger baiting: this project is funded by the RSPCA and was undertaken by WDNAS. The project developed a microsatellite DNA profiling system to allow evidence items to be linked to a specific badger.
- Tiger bone protocol project: this project was funded by Defra and developed a tiger bone DNA test to identify powdered tiger bone in Traditional Asian Medicines
- A Review of Current Wildlife Species Genetic Research: this project, funded by Defra and undertaken by TRAFFIC and LGC identified a priority list of wildlife species in trade, where DNA research could assist law enforcement
- DNA test for shahtoosh: Defra funded the development of a shahtoosh DNA test to identify wool and fibres from Tibetan antelope
- Forensic identification of illegal wild meat entering the UK: this project funded by Defra and IFAW and carried out in conjunction with HMRC by WDNAS tested unidentified meat products entering the UK to determine the source species using DNA techniques
- Immunological detection of bear products in traditional Asian medicines: this project was funded by WSPA and undertaken by WDNAS. It developed an immunological assay for the detection of illegally traded bear products in South-East Asia. The assay is incorporated into a field based testing kit so allowing on the spot detection of products containing bear
- Genetic technique development for the forensic identification of CITES listed timber and wood products: this project is being funded by Defra and undertaken by WDNAS and RBG Kew. Its aim is to provide proof of

concept for the development of DNA-based timber identification techniques, and will include all the necessary stages in the production of a validated forensic test for ramin in the first instance.

The developments in forensic technology now mean that there are techniques other than parental testing via DNA that could be utilised in the fight against wildlife crime. This includes Carbon14 'Bomb' testing, stable isotope technology, forensic palynology and forensic interrogation of computers. They are likely to be others and these need to be identified.

Further work and research is required to support CITES priorities in tortoises, parrots, Caviar, traditional medicines and eels.

The forensic working group also liaises and networks with other organisations including Wildlife Health Services. Wildlife Health Services teach and train students and others in a range of disciplines, including forensic science. WHS provides a specialist forensic service based on their qualifications and experience. While the emphasis is particularly on legal cases in which animals (and, occasionally, humans) play a part, the techniques that they use are also applied to other fields of forensic science. Examples of WHS work includes live animal examinations, necropsy, identification of bones and soft tissues, laboratory techniques and the identification of pests and contaminants of food. WHS provides a service in cases where techniques are needed, or desirable, that either supplement methods such as DNA technology, or yield valuable information in situations in which DNA (etc) cannot be used effectively. Often, the technology WHS applies can answer questions that are not adequately addressed by DNA and other molecular techniques. Examples include ageing of wounds, determining the circumstances of death and assessing pain and suffering. On occasion, non-DNA techniques may provide adequate evidence more quickly or cheaply. Insofar as research is concerned, WHS is involved in small projects, usually prompted by the specific needs of an investigation: we seek to provide evidence-based information on diverse forensic issues.

In the context of the review, the Forensic Working Group see a need for better recognition of the skills and experience of people such members of PAW and diverse individuals who are able to provide services that fill gaps that cannot be answered by molecular or other sophisticated, but often expensive, techniques. Those investigating crimes, as well as those prosecuting and defending cases, need to be more familiar with the full range and appropriate choice of investigative science that can contribute to the production of sound evidence. In our work we seek to have links with a wide range of bodies, both within the UK and overseas. Some such as PAW, offer many opportunities for collaboration and sharing of knowledge and resources. However, the field of "animal forensics" (of which the detection of "wildlife crime" is part) and the role it plays in the judicial process is often not fully recognised by organisations and individuals who are working in more technological areas of forensic science. There is, we believe, a need for a more unified system within the UK so that those involved in forensic work,

whether it relates to humans, animals, the environment, or a combination of these, are in close contact and constantly benefiting from one another's experience and research.

There is no current strategic approach to how forensic technology has, is or might be utilised to tackle wildlife crime in the UK. Such an approach is overdue and now needs to be addressed as other areas of wildlife crime work are being professionalised.

FREELANCE SCIENTISTS

Background

We are part of a group of scientists working essentially as free-lance scientists but with support from the University of Gloucestershire, The University of Aberdeen, the Natural History Museum (London), Birkbeck College (University of London), and Universidad Complutense de Madrid.

We have been responsible for developing the sciences and appropriate protocols for forensic ecology, botany, palynology, and mycology. These have been used successfully in over 200 criminal cases over the last 17 years. We are both expert witnesses and have been cross-examined in many courts in the UK and Ireland. In many of these cases, our evidence has provided the only forensic evidence in the case. Also, in a fairly large number of cases, our evidence has been responsible for confessions and obviation of court procedures when presented to Defence Counsel and Defendants. We have been engaged in mostly prosecution work in cases involving murder, rape, and abduction but have also contributed to several defence cases.

We regularly lecture to police, and to post graduate students, both at home and abroad, and present our findings at national and international conferences of our peers. We are actively engaged in publishing our findings.

1.0 What work relevant to forensic science is being done in your group and what are the opportunities for the future?

We have wide areas of ecological expertise and skills in identifying whole plant and fungal organisms, including their propagules, and fragmentary, and decayed remains, in the field and the laboratory. Between us, we also have extensive knowledge of soil science, archaeological techniques, the distribution of living organisms, and taphonomy of dead ones. We both have over 40 years experience in our respective fields and extensive peer-reviewed publication records. We have been applying this long experience in the forensic context.

1.1 Nature of the work: We have successfully contributed to cases involving the following over the UK and Ireland:

(a) Linking objects, people, and places (trace evidence).
(b) Estimating post-mortem intervals
(c) Estimating time of deposition of corpses
(d) Identifying offender pathways
(e) Helping to establish causes of death employing evidence from: pollen, spores, fungi, plant material, and inhaled fibres and other objects.
(f) Location of clandestine graves and bodies at both large (country-wide) and small (site-specific) scales.
(g) Identification of sequences of events, and their temporal relationships, at crime scenes.

(h) Providing evidence of poisoning, and times of death, from gut contents analysis.
(i) Differentiating murder sites from deposition sites.
(j) Providing evidence of disturbance of crime scenes prior to police involvement.

1.2 Nature of research: It is essential to stress that every case that presents itself is a vehicle for research since no two cases are ever the same. In fact, the case work has formed a very large, but informal, database of information. Something new is learned in every new situation.

We currently get small projects completed by M.Sc. projects in courses in which we teach. These are Birkbeck College and The University of Bournemouth. However, we also have facilities at The University of Aberdeen and the University of Gloucestershire and have two small, externally-funded projects just about to start. One has been funded by the EU and the other by a crime writer. Attempts to gain funding from formal bodies have been discouraged as their funding remits are so narrow.

These research projects are concerned with technical and methodological matters relating to: effects of chemical processing on palynomorphs (pollen and various kinds of spore which provide trace evidence; growth rates of fungi on different substrates (including cadavers) for providing predictive models in estimating post-mortem intervals; temporal effects of gut activity on foods; investigation of sparsely-palyniferous surfaces on transfer of palynomorphs.

We are keen to teach, supervise research, and pass on our skills, but there does not appear to be a mechanism to do so under present public funding arrangements.

2.0 What previous and current research partnerships do you have with forensic science providers, police forces, the National Policing Improvement Agency etc.

One of us (PEJW) has dealt with two major providers in the past. However, the management and staff failed to appreciate the nature and requirements of our work, and neither was able to provide the necessary support. Their consultative methods were poor; both the routine work (which generates large amounts of

valuable information), and plans for research, were not realised for a variety of reasons. Many years ago, it was suggested by NPIA (when it was Centrex) that facilities should be provided for us within their organisation so that we could achieve continuity in both the development of the disciplines, and training for the future. This never materialised.

Individual police forces have provided small amounts of money for research in relation to particular cases.

3.0 Can you give good examples in the forensic science field of translation of research into practice, and also any examples where this has been difficult or problematical?

Ecology covers a very wide range of disciplines ranging from soil science to animal behaviour. Research into any of these areas will enrich the knowledge of the forensic ecologist. Our specific, highly specialised, disciplines of palynology, botany, and mycology, are very well established and there is little need for research into the basic theoretical aspects. However, the protocols, procedures, and "mind-set" necessary for the forensic context needed to be developed.

Wherever trace evidence, picked up from pertinent places, is relevant, the issue of transfer and retention is important. However, without fail, in every case, these factors will vary. Research papers have been submitted for publication where experiments in these factors have produced seemingly impressive results. However, it must be stressed that no predictive models will accrue from them because of the highly diverse and heterogeneous nature of all the factors involved. One must question whether this approach is, therefore, valuable.

Each case can pose particular questions that need to be answered for the evidence to be credible. For example, we recently needed to do small-scale experiments with colour changes in lichens to demonstrate the effects of being covered. The results enabled us to give time estimates for the length of time part of a corpse had lain *in situ*.

In another case, where a post-mortem interval was needed, fungal growth on carpet and cushions provided temporal evidence. After identification of the fungi concerned, and growth experiments with these species under controlled conditions, we were able to give a date for the spatter of body fluids that had supported the fungal growth. Confession of a suspect confirmed the date we had given.

Field experiments with growth responses of plant species found at a murder sites have enabled us to estimate the time of deposition of corpses. This was

demonstrated in Operation Fincham (the Soham murders). We estimated approximately 14 days and the interval was, in fact, 13.5 days. This contradicted the entomological evidence which stated 4 days interval. Confession from the offender confirmed the interval of 13.5 days. This demonstrated the robust nature of evidence capable of being provided by plants when compared with that given by insects.

We have also been engaged in research into bacterial numbers associated with cadavers in soils, and the effects of temperature in the release of volatile carbon compounds from cadavers and the resultant impact on fly infestation.

We have very many examples of small-scale experiments conducted at our own expense, and from small grants awarded from various sources. The results of these have enriched the database of forensic knowledge in environmental forensic science. Details of these can be provided if necessary.

As a consequence of profiles of both organic (pollen and spores etc) and inorganic (mineral particles) being so site and situation specific, to the extent that they have been referred to as providing “fingerprints”, few databases or models are likely to be of practical value. In some cases considerable public research monies have been used in projects aimed at developing databases. The value of ones including pollen and mineralogical information must be questioned. The main databases that are relevant to our work either already exist (e.g. Botanical Society of the British Isles distribution maps) or are being compiled by other organizations (e.g. the British Mycological Society’s Fungal Records Database of Britain and Ireland) with inputs from numerous citizen scientists.

4.0 What do you see as the opportunities for, and the barriers to, the funding of research relevant to forensic science?

The opportunities are considerable in support of some aspects of our work, for example in the development of standard protocols for work on fungal growth in the relation to the determination of post-mortem intervals.

Fungal palynomorphs also enhanced palynological profiles very greatly and there is an international need for the development of a comprehensive photographic atlas of fungal spores and other structures. At present, the application of fungal data in forensic work is severely restricted by a lack of scientists with the relevant experience and knowledge. This would be a major undertaking, but the UK is uniquely positioned for such a task as it has the world’s largest collection of fungal material (at the Royal Botanic Gardens Kew). It must be stressed, however, that this would not be a suitable project for a student or inexperienced mycologist.

There is also scope for investigating the nature and potential of palyniferous surfaces, and specific taphonomic inconsistencies. However, there does not appear to be any vehicle for the public funding of relatively short-term and small-scale research. The current Research Council system, which is confined to supporting Universities, is not appropriate as it focuses very much on theoretical rather than pragmatic investigations.

There is also the problem of the three-year grant system because, for example, a fungal spore manual (see above) might take much longer to compile whereas meaningful results from other experimental work can be obtained in much shorter time frames. Furthermore, the M.Sc. project student resource could be exploited more effectively if relevant projects were to attract adequate funding. Many are directed towards highly theoretical topics with little foreseeable utility.

5.0 What are the important networks and how useful are they? Do you have a specific international collaboration you would wish to draw to our attention?

We belong to an extensive network of internationally-renowned botanists, palynologists, ecologists, and mycologists. We collaborate at various levels such as writing of research and review papers, exchange of reference material, evaluating each others' work critically, exchange of advice on various aspects of our work. We also have links with the Swiss Forensic Institute. In particular, we are discussing the production of a definitive textbook on forensic palynology and mycology with Dr Dallas Mildenhall in New Zealand. We have also collaborated with The Macaulay Land Use Research Institute (Aberdeen) in previous three-year, government-funded research projects.

We are also both members of the Geological Information Network working within the International Union of Geological Sciences, and are involved in writing guidelines for use in the international community. Although termed "geological", the network actually includes chemists, geographers, soil scientists, and environmental biologists. In our view, it would be better named the "Geosciences Information Network" since it includes so many non-geologists who are, nevertheless, engaged in analysis of geologically-derived materials.

We have contacts with other forensic scientists through the Forensic Science Society. These contacts are useful for exchange of information. However, our disciplines are so poorly represented amongst the membership that, in our case, there is little professional challenge or support.

6.0 Are there any other issues relevant to our terms of reference that you would wish to comment on?

Based on the submitted papers we review in our roles as reviewers for international forensic journals, we are concerned at the lack of understanding of many university-based scientists, and other academic institutions serving various areas of industry, as to the needs of forensic case work. Presumably, this is because they have had little experience in working directly with the police or on actual cases. Furthermore, they have little grasp of the gravity of the outcomes of trials to which their evidence might contribute.

There is great emphasis on the development of standards and the accreditation of laboratories. However, the emphasis here is on procedures rather than personal competence. But, when constructing forensic strategies for their role in criminal investigations, interpretation of data, and presentation of the outcomes in court, it is the competence of the individual scientist that is in question rather than the protocols and facilities provided by the company or institution.

There are various grades of forensic scientist. There are those who are employed by forensic providers, are laboratory based, and are not required to give evidence. The reporting officers in these companies are required to give evidence. However, in the last decade there has been the burgeoning of specialists, some in esoteric disciplines, who have offered their services to criminal investigators. It is the “ultra-specialist” that gives the most concern and, in our view, there should be some stringent method of assessing their competence by independent and highly critical assessors who can prove their continued experience and performance in the field. Such “ultra-specialists” have offered their services to both Prosecution and Defence. In our view, the Defence specialist should be as competent as the Prosecution one.

There seems to be no national plan for maintaining continuity of expertise in all aspects of forensic science. This is a matter of great concern. There appears to be a plethora of forensic science courses in universities, but relatively few in individual sciences. We are concerned that our own disciplines have declined dramatically in the last 20 years and there has been little attempt to prevent their gradual disappearance from University curricula. It is now unclear from where the next generation of forensic palynologists and mycologists can be recruited. These are especially worrying as these have proved to be extremely valuable areas of forensic science which have contributed to numerous convictions in cases of serious crime.

HOSDB RESPONSE TO THE HOME OFFICE REVIEW OF RESEARCH AND DEVELOPMENT IN FORENSIC SCIENCE

For many years HOSDB has supported a programme to provide safe and effective fingerprint development and imaging techniques for use in police laboratories and at scenes of crime. More recently this has expanded into work to develop footwear mark recovery techniques. During this work, we have engaged successfully with academia in a number of ways, provided input to industry partners and worked with police practitioners to identify and resolve issues.

Other HOSDB programmes support other forensic areas (eg e-crime, drugs, CCTV) but this is not specifically considered here.

Issues that the review might consider are

1. Forensic science research is drawn from a wide range of scientific disciplines.

There exists a generally accepted definition of forensic science in terms of its outputs. The inputs in terms of the sources of R&D cannot be defined as they originate from a broad spectrum from the highly academic to 'happy accidents'. Spotting the opportunities for exploiting these requires a similarly broad view. This is an activity that has not been managed comprehensively, even in a field as long-standing as fingerprints, although HOSDB has been vigilant in this area.

2. Academic research is not sighted on the needs of the police service.

With a few exceptions where universities have built links with the police, academic research has worked without a clear idea of the ultimate practical application. This, linked to the lack of a clear route to test the idea with the police, has led to inefficient use of resources.

Case Study 1

Swansea University's identification of the use of their Scanning Kelvin Probe for fingerprints was picked up in the media. A flurry of activity ensued in the fingerprint world before HOSDB started a coordinated programme to work with the university to highlight the various needs of the CJS, in terms of the practical application of the technique.

3. The police service is not good at articulating its needs to academia

Case Study 2

St Andrews University was awarded EPSRC funding to develop a light source for fluorescence examination in daylight of developed fingerprints. In this instance an inexperienced police force had been consulted but wrongly identified the need and consequently the work was misguided.

Extra effort is being made though the police Science and Innovation Strategy to articulate their capability gaps. This has been much needed to give direction to academia to focus their efforts and reap the benefits of joint applications for funding.

It is hoped that problem areas will be identified, rather than potential solutions. In this way, it should be possible to take a more integrated approach to police applications of forensic science: for instance finding the best method for developing fingerprints on a mobile phone will be of limited value if it compromises DNA and other evidence. (The proposed HOSDB-Fera collaboration may assist here.)

4. The route for development of research projects is poorly supported

The effort (time, planning, funding and human resource) needed to implement new ideas in forensic science is often not recognised and therefore the coordination of the necessary activities is weak. The level of autonomy within forces also means that roll-out may be fragmented, less attractive to industry and leads to inefficiencies and inconsistencies within the CJS. An example is the roll-out of 'Remote Transmission of Crime Scene Marks'.

5. Collaboration between interested groups is not maximised

Collaboration offers a number of benefits: sharing of knowledge and stimulation of ideas, avoiding duplication of effort and opportunities for joint funding. There is currently no working collective approach between interested parties, including those across government, although NPIA is now working in this area. Consequently, the benefits currently realised through existing partnerships represent only a small fraction of those possible through better employment of effort.

Case Study 3

HOSDB has run a series of workshops with university, government and police identifying possible surface technologies for fingerprint development. The collective thinking has had the desired effects of collaboration, with more joint programmes and funding applications.

6. Peer review of research studies for police applications is weak

The level of publication in forensic science is generally considered to be low, and possibly affected by commercial sensitivity. Generally, there are few standard methods for forensics research and this can lead to inability to compare studies or lead to questionable pieces of work, especially in the context of police applications. For example, a method that only works on fresh fingerprints that have been groomed by rubbing the hands on the face are not realistic for police applications but still find their way to publication in respected journals.

Summary and recommendations

There is currently huge energy in forensic science, but I liken it to 'bumper cars'. That is, the energy is evident from the great interest from the public, academia and all those working directly with it. However, without direction and greater coordination, the energy is misplaced, lacks direction and occasionally ends up in a head-on collision.

Having the energy should mean that, with correct guidance, it can be redirected. There would, perhaps, be greater concerns if there were no energy there at all.

Therefore, a recommendation is made to provide a means of encouraging better collaboration between academia, industry and CJS partners which would operate across government departments, with the aim of

- Establishing a greater understanding of the capability gaps of the police, so that clear operational requirements can be developed to guide research in forensic science
- Establishing appropriate forums to draw on the extensive knowledge in universities and elsewhere, including internationally (eg ENFSI) to identify areas of scientific work where possible solutions could be found
- To articulate to universities the skills that will be needed from researchers
- Providing a central communication route to ensure that new ideas are managed appropriately, so that they are
  - fully evaluated scientifically
  - challenged for their operational suitability/applicability
  - tested for broader implications, including integration of other forensics
- Ensuring visibility of possible funding routes for interested parties
- Ensuring adequate peer review of potential developments
- Establishing routes to implementation, which are realistic in terms of the effort required

The need for a dedicated resource to achieve this is evident. In the current climate it may be impractical to realise this as an option. However, without careful management, many more resources will be wasted unnecessarily.

Dr Valerie Bowman
Programme Manager: Fingerprint & Footwear Forensics

INTELLECT

Introduction

Intellect is the UK trade association for the IT, telecoms and electronics industries. Its members account for over 80% of these markets and include blue-chip multinationals as well as early stage technology companies. These industries together generate around 10% of UK GDP and 15% of UK trade. Intellect provides a single voice for these industries across all market sectors, and is a vital source of knowledge and expertise on all aspects of the technology industry.

Intellect welcomes the opportunity to input into the Home Office's *Review of Research and Development in Forensic Science* and our members have chosen to highlight the issues of relevance to the technology industry and upon which their expertise is most acute. We would welcome the Home Office's views on our submission and would be happy to organize a formal meeting to discuss the ideas outlined below.

Intellect Submission

Strategic Approach

1. Intellect's members feel that there is an absence of a strategic approach to the government's assessment of, and investment in, research and development in forensic science.
2. The Home Office and the Police Service articulate neither their problem set, nor their objectives and processes for achieving these in relation to forensics. Unless industry understands what government aims to achieve with forensic science (and who wants to achieve it), it is unlikely that the private sector will fund substantial research and development in this area.
3. Intellect recommends establishing a system for identifying capability gaps, prioritising and quantifying problems that require research.

Funding of Research & Development

4. Forensic Science is a niche market, which government, as the main driver, must stimulate. In this instance, government must abandon the presumption that this research will be driven by commercial entrepreneurship.
5. In the absence of a wider market, government financing of R&D is crucial. For example, the NPIA's Forensics 21 Programme focussed on industry's Rapid DNA solutions.1 When four providers were invited to discuss the Agency's objectives for a 12 month pilot, it transpired that there was no funding to assist the police forces to implement the technology and, without a guaranteed market, this was an unappealing commercial proposition. This diverges from the approach used by the Ministry of Defence, when 2 bidders for major infrastructure procurements are funded throughout the competition stage until one is successful with the bid.

1 For further information see: National Policing Improvement Agency, Forensics21 Programme. http://www.npia.police.uk/en/10432.htm

Fragmentation of the market

6. There is a plethora of government organisations (including HOSDB, NPL, BSI, OSCT, CESG, GCHQ, TSB) that fund academic research in the forensics

space. There ought to be better coordination of research funding, along the lines of the coherent approach taken in the US by the channelling of funds through the National Institute of Standards and Technology (NIST).

7. This fragmentation means that if a supplier has mature technology, there is little guidance on which agency to approach, and rarely a consistent approach to its assessment.

8. One particular example experienced by an Intellect member was the differing requirements expressed by the National Policing Improvement Agency and the Home Office Scientific Development Branch for the proving of the integrity of digital information.

9. In the US, the FBI defines a problem to be researched by academia. The resulting research is then published for commercialisation. Companies then compete in a customer-funded competition to produce an efficient and effective technological solution. At the very least, the publication of a list of academic research undertaken in this space within the UK would be of benefit.

10. A further example of best practice is the FBI's publication of an approved list of technologies for delivery mechanisms of forensic evidence. For example, in responding to a tender a company only needs to demonstrate that its product is accredited to the standard specified in the relevant FBI appendix, simplifying the accreditation process without sacrificing rigorous assessment.

11. Investment in R&D would be facilitated by effective quantification of the market. Using the example of Rapid DNA, if companies are to invest in the technology, government should indicate the number of DNA samples collected across the police forces.

12. In the competitive dialogue stage of the procurement of forensic technologies, the inclusion of the National Physical Laboratory or HOSDB as independent experts is crucial to the communication of technical requirements.

Accreditation

13. A significant obstacle to investment in R&D in forensic science is the forensic integrity of data; emerging forensic technologies, such as voice recognition systems, are not accepted by the existing legal system.

14. A common legal objection to the use of evidence based on such technologies is that there is a lack of process for their standardisation.

15. This is a legal, not a technological, problem. The government should specify what certification or accreditation process it deems appropriate, while avoiding a standard that can only be implemented by one supplier.

16. Intellect recommends that it should be the role of the Regulator to negotiate with the Crown Prosecution Service and the Judiciary acceptable terms of certification for, and what precisely is expected of, the forensic technologies. Without this, the supplier community is unlikely to assume the risk of investing in R&D.

17. A further suggestion is that tenders could specify that a product has to be tested by an independent expert, such as the NPL. If this is not a requirement, companies are unlikely to disadvantage themselves against competitors by undergoing such an assessment.

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LGC FORENSICS

Review of Forensic Science Research and Development : Response from LGC Forensics

Introduction
Research and Development in Forensic Science

LGC Forensics is committed to providing ever-better forensic services and has made significant investment into forensic R&D, including all the quality assurance and validation processes necessary to demonstrate that new techniques are fit for use within the criminal justice system. However, it is important to acknowledge that many aspects of modern forensic provision are *mature*, '*battle-hardened'* and *incredibly sensitive* applications of science. Whilst there is a fundamental requirement for ongoing innovation, research and development and expansion of scope to evidence types currently outside our repertoire, these advances will be hard-won, requiring the application of ever greater effort. Not every R&D project can generate another *revolution* in our capabilities; much will rather represent an *evolution* of capability. Against such a background, and in common with the funding of scientific research in general, LGC Forensics must carefully consider how we can most effectively apply the R&D resources at our disposal to make the incremental advances that are the bulk of forensic R&D achievements, as well as conducting horizon scanning to identify and capitalise on technologies or processes that may offer the *knights move* introduction of a revolutionary capability.

LGC is comprised of four divisions:

- **LGC Forensics**
- LGC Genomics
- LGC Science and Technology
- LGC Standards

We are a company that invests in research and development both directly and indirectly, and capitalises on the divisional structure above. Internally, through close ties to the other three divisions of LGC, LGC Forensics stays abreast of innovations and capabilities in the broader analytical sphere that could be developed and applied to the betterment of forensic service delivery. Externally, through relationships with academia and industry, we access 'not invented here' technologies and processes that enable us to develop novel capabilities, with demonstrable potential to enhance our service delivery.

Forensic scientists are expected to be fully *au fait* with relevant developments in their fields and have to be prepared to face rigorous challenges in court. They are therefore obliged to keep up with developments in many different areas, from new analytical technologies and consumer products, through to developments in legal, statistical and quality assurance best practice. This requires continuing investment to develop and improve methods, while ensuring that reference databases remain current and that our interpretations remain appropriate. All new processes also have to be validated, and preferably accredited, before being offered for use within the Criminal Justice

System. There is therefore a requirement for continuous investment in service development merely in order to remain current, in addition to that required for making significant advances.

LGC is committed to maintaining its reputation and position by ensuring that the science we deliver is continually enhanced and advanced. We do not recognise some recent media suggestions of a commercial company that will 'cherry-pick' and deliver only the simplest, most profitable services. Delivery of only the routine, well established or high volume range of forensic services is far from the commitment to forensic development of the forward-looking company that is LGC.

LGC is driven by an ethos to do *better* than we did before. LGC Forensics' vision of "*Science for a safer world"* demands that we do not merely *keep pace* with current criminal activity, but rather we *draw away*, by enabling a broader range of ever-better analyses.

Section 1 In-house and Collaborative R&D

Scale and Scope of R&D

LGC Forensics performs R&D across all of the forensic disciplines that we currently provide. In recent years, research and development in forensics has been dominated by DNA analysis, and this has been reflected in the mix of projects that we have undertaken. To this end we have a dedicated R&D team available for work on prioritised projects in DNA, while R&D within other disciplines is carried out through provision of resource on a project by project basis. In terms of staffing, this latter resource is most often drawn from our case-working employees, who are often best placed to understand the context within which we have to operate and the benefits to be had by development of a new capability.

LGC Forensics maintains a dedicated DNA R&D team based at our Teddington HQ. We also support a large number of individually sanctioned DNA and non-DNA projects within all other disciplines, ranging from small 'tactical' process improvement projects through to very large projects where special dedicated teams are built. One such large project is our 'RapiDNA' initiative, which had its genesis within our Science & Technology Division, but now employs a dedicated multidisciplinary team of 14 full time staff within the Forensics Division. We are currently engaged on over forty other projects, ranging from improvements in gun shot residue (GSR) analysis through studies into the persistence and migration of glass shards on clothing, to the development of methods of drugs analysis for novel synthetic 'legal highs' and the development and introduction of automated systems for current DNA profiling.

- Dedicated DNA R&D capability in Teddington HQ
- Other projects on a case by case basis

LGC Forensics invests in research and development through:

- A research and development review system that captures all proposals for potential R&D projects from our staff, and assesses and supports work where the proposed work is seen as valuable.
    - ‘Innovation days’ to engage directly with staff
    - Novel ‘iThink’ electronic tool to capture innovative suggestions from staff
        - This tool compliments a repository of Company knowledge and expertise called ‘iKnow’
- A dedicated team of DNA R&D staff which is maintained for the invention, assessment and development of both ‘home grown’ and ‘imported’ technologies. This team is based within the LGC Science & Technology Division, ensuring efficient cross-fertilisation from other innovative work within that Division.
- Regular assessment of the research potential of other, non-DNA, projects and, where defined criteria are met, dedicated teams are constructed to deliver these projects.
    - R&D Strategy Meetings, run using a ‘Stage Gate Process’, and the principles of ‘PRINCE2’ project management. This process is currently in development to maximise benefit, whilst minimising bureaucracy.
- Engagement with academic institutions and the commercial sector.
    - Academic collaborations are a current focus for the Company, assessing opportunities to work on issues that will ultimately transfer capabilities to provide service offerings.

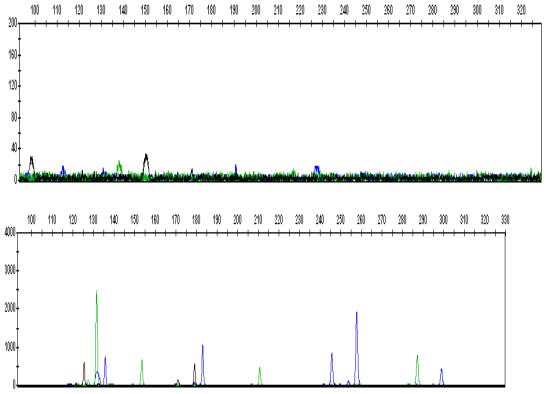
DNA has tended to receive more R&D investment than other disciplines, and there is still great scope for the development of new applications of DNA science. However, the forensic community cannot exclusively carry out research in DNA analysis to the detriment of other case types. Some types of non-DNA casework tend are more time consuming and labour intensive, making them slower processes where the outcome cam be more *subjective* (than DNA) and therefore based on the experience of the forensic scientist. Making non-DNA casework more efficient and less subjective, is an area ripe for research and development.

LGC Innovations and their Impact

LGC is an innovative company, capable of independent technology development and working with others to evaluate, optimise and adopt technologies from elsewhere. LGC Forensics has conceived, developed, optimised and introduced novel processes that have directly impacted, or will in future impact, forensic service provision. Some recent examples are:

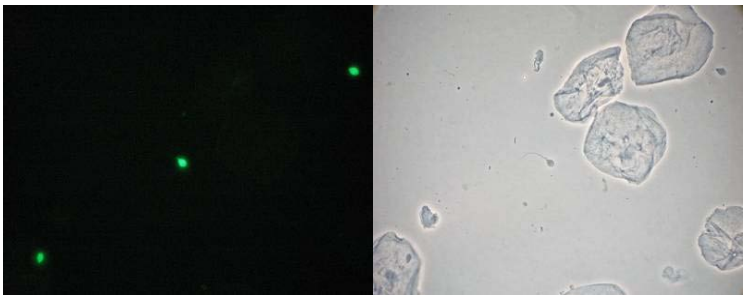
- **DNA SenCE** is an *enhancement* technique that has enabled the analysis of the very smallest amounts of ‘trace’ DNA, without the need

to use the ‘increased cycle number’ amplifications which have drawn criticism, for example, during the Omagh bomb trial.
    - Successes achieved where standard analysis may have failed to generate a result, without the complication of justifying ‘increased cycle numbers’.



DNA Sense has the ability to ‘enhance’ DNA profiles without using additional cycles of amplification. The image on the left has been *enhanced* by DNA Sense to generate the image on the right. In this example, the input DNA was effectively ‘less than one cell’. Consequently, it is to be expected that only a partial profile will be obtained, however, those peaks that are identified can be recorded with confidence.

- **‘Mix-IT’ and Familial Testing Algorithms** are statistical methodologies developed in house to enable:
    - the rigorous statistical analysis of ‘complex’ DNA profiles where there is more than one individual’s DNA present
    - the analysis of DNA where the individual is not present on the NDNAD, but a close relative may be
- **Animal DNA testing** is a novel service developed recognising that ‘companion animals’ can leave biological material that is informative in crime investigation.
    - This capability has recently enabled the conviction for murder of an individual through DNA left by the assailant’s pet pit bull terrier.
- **‘Legal High’ drugs analysis**. Having access to reference materials for novel psychoactive substances purchased on line, and ultimately sourced as ‘standards’ via our sister division LGC Standards, we are able to respond to the rapidly moving target of synthetic drug manufacture and supply.
    - There is a significant R&D requirement just to maintain our capability in this field; almost ‘running just to stand still’.
- **Anti-Sperm Antibodies** (both commercial and in-house developed) can be used to label sperm cells specifically, providing improved resolution to permit greater rapidity and certainty in ‘slide searching’.



Fluorescent antibodies against sperm highlight where these small cells are (fluorescent green spots, dark image) even in the presence of very much larger epithelial cells (grey image is the same slide, under white light illumination). This commercially available format requires optimisation for use in our laboratory; with development commencing April 2011.

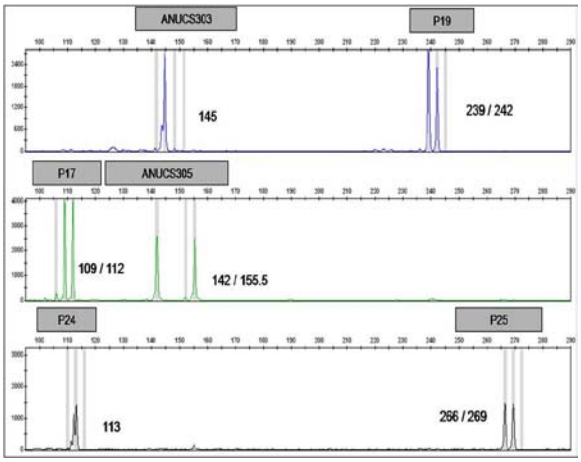
- **RapiDNA** is a novel method of generating DNA intelligence in a decentralised (non-lab) environment. The technology is designed to be used by a non-technical operator, changing the landscape of *where* and *by whom* useful forensic evidence might be generated.
  - We view this technology as having the potential to change radically the way DNA analysis is performed and DNA intelligence can be utilised.

The RapiDNA instrument is being designed and constructed in house, together with the HyBeacons chemistry the instrument employs. An LGC-designed and fabricated sampling device and onboard analysis software also contribute to this landmark R&D project.

- **Automated PACE DNA Analysis** is a sophisticated and very high throughput robotic system for the analysis of buccal swabs collected from arrestees to populate the National DNA Database.

Our automated PACE line comprises sophisticated robotic liquid handling systems enabling the processing of large numbers of buccal swabs in a virtually human operator free environment. The system uses LGC's proprietary 'Sbeadex' DNA extraction technology, invented and manufactured by our sister division LGC Genomics.

- **Cannabis sativa genetic testing**, to provide intelligence on the genetics of plants seized from different cannabis cultivation sites, demonstrating potential links between 'farms'.
  - In-house *hexaplex* (six tests in one tube) has been developed.



The impact of our R&D can be seen in terms of:

- Ability to analyse materials previously beyond our established abilities
- Improved success rates with current sample types
- Faster, more automated analyses
- Reduced costs.

As well as the development and introduction of new forensic services, we seek to enhance current processes through a program of continuous improvement. As mentioned above, this is led by encouraging and exploring suggestions and observations from the forensic scientists executing our current processes.

Continuous improvement projects normally culminate in the publication of an internal 'Technical Note', issued to disseminate the learning from the project, and to serve as a means of determining whether, as a result of the project, our Standard Operating Procedures should be modified to capitalise on the

research findings. Where the results of a project are of sufficient merit, the Company encourages the publication of the research in peer-reviewed journals.

Partnerships

LGC is fortunate to employ some 1,400 talented staff across its four divisions, enabling effective multidisciplinary research and development within the Company. However, we benefit from wider collaboration and we are actively engaged in establishing relationships with Academia and Industry.

Academic Collaborations

We have MoU and CDA agreements (completed and in preparation) with a small and select number of universities which are regarded as offering quality training to MSc and PhD levels in forensic disciplines. Through these relationships, we seek to identify expertise to collaborate on questions that we might struggle to address in-house. It is our desire to establish academic partnerships where the relationship benefits both parties; we do not view such arrangements as one directional. The type of work best suited to this type of collaboration will often be more speculative or longer term research and development work than we would necessarily be able to support in isolation in house.

- Speculative (*blue sky*) research
- Longer term research

Industrial Collaborations

LGC will often want to access materials or expertise that exists within the commercial sector, and we have established relationships (under CDA) with several companies with established reputations in the scientific (and specifically forensic) sector. The R&D funding available in a large multinational commercial company is inevitably greater than exists within a 'fee for service' company such as LGC Forensics. These collaborations can translate into products that are highly sophisticated and reliable or which can offer ever greater levels of sensitivity.

- Instrumentation
- Reagents
- Consumables

However, we cannot realistically expect to 'plug and play' any new technology, be it consumables or instrumentation. We expend significant R&D time on assessment of available products, optimisation of their use in our hands, and then challenge and validation of systems to prove their reliability and benefit. Only after a thorough review process will we purchase a novel technology and take this through the rigorous forensic validation and accreditation process required to enable us to offer a new service. Some technologies prove to be unsuitable for forensic use. LGC has recently, for example, thoroughly explored the potential of applying mass spectrometric techniques to

mitochondrial DNA sequencing and pathogen detection, but found that the commercially available technology was not suitable for development for forensic applications.

Funding

Our internal Research and Development, and support of external R&D, are enabled almost exclusively through funding from the Company.

Over the last year , LGC Forensics have directly invested over £2.3 million into our in-house R&D efforts, a significant proportion of which is invested in our RapiDNA project. In addition, through association with our sister divisions, the Forensic division has benefited from an 'LGC Corporate' investment in R&D well in excess of this figure.

Section 2 Assessing and Accessing the Latest Technologies and Techniques

We regularly review all R&D activity through two complementary management structures.

- The **R&D Strategy Group,** which is a high level group of senior managers, chaired by the Chief Forensic Scientist, and including the Managing Director and the Finance Director LGC Forensics. This group sanctions the application of resource to specific projects, evaluating each opportunity and, if appropriate, reallocating resources from casework to R&D, or even creating new positions.
    - Separately from this group, but with close ties, the DNA R&D Group meets monthly to review and forward plan DNA project activity.
- The **R&D Delivery Group** is a team that reviews smaller tactical or continuous improvement projects that are largely proposed and executed by case-working forensic scientists. These projects tend to have a focused practical application to address a specific issue faced by caseworkers.
    - The DNA R&D Group again feed back onto the R&D Delivery Group.

Information, potential projects and opportunities are brought to these forums through a variety of mechanisms, including collaborative relationships, conference attendance, literature review, in-house 'Innovation Days' and the recently established 'iThink' company register of ideas that Company employees propose. There is always more potential project work than it is possible to carry out, so a system to triage opportunities to identify the most scientifically valuable is essential.

Our R&D pipeline is assessed through a Stage Gate review process, with each prospective project being scrutinised in order to demonstrate that the

investment being made into the project is still on track to deliver tangible benefit at the end of the process.

We have encountered situations where developments which we believe could be of great merit are hindered for reasons outside our control. An example of this is the current availability of new commercial formulations of DNA analysis systems, using 15 STRs. There are at least three new commercially-available 15 STR multiplex kits that we have assessed as being significantly more sensitive and robust than the current 'SGMplus™' multiplex kit. However, the adoption of these improved kits is being hampered by the fact that the NDNAD is not yet able to accept their output.

Another example is the use of 'whole genome resequencing', an area of research that we would like to investigate, but which we anticipate will be difficult due to ethical concerns. Although it took ten years and $2.7 billion to sequence the first human genome, this technology is rapidly becoming affordable in comparison with other forensic tests. There are examples of cases where this new capability could be of forensic utility, but, in the process of resequencing all of the DNA present, we will inevitably also inadvertently sequence pieces of DNA that have associated medical/health implications. How we address such issues whilst accessing such a powerful technology will require consultation, collaboration and research involving the expertise and views of many groups.

Section 3 LGC Forensics Links to Academic R&D

Forensic science has captured the public imagination and is now a (largely fanciful) staple of television entertainment. There has also been an expansion of the number of further education institutes offering BSc and MSc courses in *forensics.* LGC benefits from this in receiving numerous approaches from academia to collaborate on R&D work, including the potential to sponsor work on PhD level R&D. Although sponsorship of PhD research is not a development avenue we are presently capitalising upon, we are in discussion with four academic institutions investigating the potential to enter into this type of long term relationship.

It is potentially of most benefit to collaborate with academia on those projects that are more speculative (perhaps *blue sky*) and on those projects that require dedicated effort over a period of years. However, we also value the contribution of shorter term R&D, such as can be enabled by MSc project work. Every year we host around ten MSc students at our various laboratories to help address research and development projects that are relatively small, self-contained pieces of work, suitable for investigation in a time frame measured in a small number of months and for presentation to the parent academic institution in the form of a thesis, contributing part of the students' degree requirements.

A number of LGC's experienced employees have established relationships with academia (Kings College London and University College London, for example) that enables them to share their expertise through teaching appointments. Lecturing on MSc courses strengthens the link between the

Company and academia, while ensuring that the subject being taught is relevant to current casework demands. This close association will of course also facilitate the identification of any fertile areas for further R&D that might exist between the Company and the Institution.

Section 4 International Networks

The international community of forensic science is tight knit, supportive and highly collaborative. LGC Forensics has a long history of participation in international conferences and international organisations such as the European Network of Forensic Science Institutes (ENFSI) and the International Society for Forensic Genetics (ISFG). LGC enjoys a privileged position as the only'commercial sector' member of ENFSI, with the other members being exclusively government-funded and academic institutions. As the UK forensics market has developed towards a commercial model more rapidly than other European countries, we are very aware of the responsibility we bear in demonstrating that the commercial sector can contribute to the development of forensic science within ENFSI, rather than being perceived as an organisation that will *parasitically* take from ENFSI, without making meaningful contributions.

International forums such as ENFSI, ISFG and the European DNA Profiling Group (EDNAP) provide a stimulating environment for the generation and cross-fertilisation of ideas and for the establishment of research collaborations both at the individual level and, more formally, through organised trials of new technologies.

LGC Forensics has integral involvement with international forensic networks, being actively involved in Working Groups of ENFSI, and in collaborative research across a range of forensic disciplines. For example, we are involved in a European network (AGIS) looking at recovery of evidence from fingerprints on cadavers and, as part of the same project, have involved the Anatomy Department of Oxford University to produce best practice methods for utilizing evidence.

Together with the international group EDNAP we are taking part in a combined research effort to evaluate a promising method to distinguish body fluids from each other, based on the analysis of specific nucleic acids called mRNA. This kind of research brings benefits in sharing of expertise while the cost of the development is defrayed between laboratories and countries, to the benefit of all. The final outcome of such collaborative R&D is also more acceptable to accreditation bodies, having undergone more extensive validation than would be possible in the same timeframe under the auspices of a single organisation.

Summary

LGC Forensics is a 'full service' forensic provider and, whilst acknowledging the level of sophistication that our current service has achieved, we strive to do better and to offer more. We seek to achieve this through the application of research and development effort in all disciplines, and in the most appropriate manner possible:

- We apply R&D effort in-house to distinguish our service offering as being best in class
    - We support R&D in all areas where justified by scientific merit or potential customer demand for new services
- Where appropriate we enter into collaborations to hasten progress, or access technologies and capabilities not conceived in-house.
    - Academic collaborations
    - Commercial collaborations
    - International forums and organisations

LTG EXECUTIVE COMMITTEE

Questions for forensic science providers

1. The scale, scope and impact of the research and development carried out by forensic science providers and related organisations (in the public and private sector).

Scale of R & D*:*
The LTG (formerly The London Toxicology Group) is a professional group of around 200 members from across the UK with a few international members giving a global perspective to our remit and access to information. The membership is broad based in terms of its service provision, specialist interests and is composed of specialists working in both clinical and forensic science disciplines in both public and private sectors.

Some members will have access to dedicated budget, staffing, equipment and facilities for R&D, whereas others will not. However, most R&D will occur in response to new demands placed on the service by its users. These may originate from clinical sources rather than forensic enquiries in the first instance (e.g. development of new techniques to detect new chemical entities) for most non-commercial laboratories; however, similar pressures are likely to be faced by those in the private sector. It should be noted that the lack of adequate funding impedes R&D activities but without these, new developments which may lead to legislative changes could be missed. Such investment could lead to proactive rather than reactive research policies being undertaken, including clinical surveillance.

It is envisaged that individual laboratories / members will contribute to this consultation exercise directly, however some of the smaller laboratories will either feel that their contribution is not directly relevant to this information gathering exercise, or will not have been made aware of it taking place. This may mean that some useful contributions may be missed.

Scope*:*
The scope of R&D undertaken by the members of the LTG will depend on their own specific interests such as epidemiology for those interested in occupational
monitoring or new chemical entities / designer drugs e.g. mephedrone and spice for those engaged in drug detection. In addition, the range of R&D activities will depend on individual members' access to resources devoted to R&D activities. Hopefully this issue will be more fully addressed by individual contributors.

Partnerships:
There will be a broad spectrum of collaborative partnerships between laboratories and between laboratories and academia with the aim of developing as broad a range of services as possible. Occasionally this will lead to peer reviewed publications that everyone can benefit from, or it may

be seen as commercially sensitive information to be retained “in-house” for organisational gain. The aim of the LTG is to disseminate current research via its meetings (5 times per year) or via its website (www.ltg.uk.net) for the benefit of all involved in clinical and forensic toxicology analysis and interpretation.

***Funding**:*
This will be better addressed by individual laboratories or members contributing to this consultation exercise.

2. The extent, and the ways in which, forensic science practice assesses the relevance of, and accesses, the latest advances in technologies and techniques.
Information on the latest developments (applications or techniques) is gleaned from peer reviewed articles or discussion with scientific colleagues at LTG meetings or from poster presentations of collaborative research projects at the December Group meeting. Wherever possible the sharing of information is encouraged, although it is recognised that some information may be sensitive, or only relevant to a sub specialty of the Group. However, access to the latest advances in technology will be dependent on financial constraints, although this situation may be eased by collaborative working practices between some of the membership and the commercial providers of cutting edge equipment.

3. *The scale and scope of forensic science research undertaken in academia and its links with forensic science practice*.
Several members enjoy collaborative and mutually beneficial links between the laboratory and academic units to develop new techniques or new applications of existing techniques to support service provision. It is essential for the future development of high level science and scientists that such links continue to be forged and developed. Once developments are brought into fruition, they may be shared with the membership at either scientific meetings or at poster sessions where the very latest trends and applications are described for all the membership to take advantage of.

One issue associated with academic research is that it typically occurs in short project driven timeframes such as 3 or 6 months dependent on the degree (e.g. BSc or MSc) which may or may not lead to developments which could be implemented. To try to overcome this and to develop a more focussed approach to research undertaken in academia, a subgroup of the LTG has been established which links in with several key universities and academic research leaders.

4. *The current and potential contribution of international research networks to UK forensic science research and practice*.
Please give any specific examples or comments.
The LTG has links with several international organisations with similar interests such as the BLT (The Toxicological Society of Belgium and Luxembourg), GTFCh (German Society of Toxicological and Forensic Chemistry), SFTA (French Society of Analytical Toxicology) and TIAFT (The International Association of Forensic Toxicologists). This gives the Group and

the membership access to cutting edge scientific developments from across the world. Occasionally joint meetings are held where members can discuss specific issues and potential develop collaborative links for mutual benefit. It is unlikely that such a breadth of access to information is available elsewhere.

THE MACAULAY INSTITUTE, ABERDEEN

In response to your email in connection with TOR and request for my views, I answer your questions for researchers.

My area of work is forensic soil science.

1. Work that has been done by myself and my group is on the following:

-development of soil databases
-search software tools
-soil biomarkers for site characterisation and linkage to SOC
-soil mineralogy for site characterisation
-soil sampling strategy at crime scenes
-soil biomarkers as indicators of recovery of human remains
-statistical approaches to the assessment of soil evidence, including Bayes.

This is largely from the project **http://www.macaulay.ac.uk/soilfit/** and Scottish Government funded core research.

Outputs:

Refereed journals:

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Macdonald, L.M., Davy, V., Brewer, M. and **Dawson, L.A.** *Towards a soil forensic database: Integration of soil fingerprinting techniques*. Soil Forensics Workshop at the Californian Association of Criminalists, 108th Fall Seminar, The Climate of Crime: Hot Topics and Cold Hits. 9th - 13th October 2006.

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Interview with Lorna Dawson in the *Sunday Post* 28 January 2007

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Characterisation and discrimination of urban soils: preliminary results from The Soil Forensics University Network. **A. Morrisson**, S. McColl, **L.A. Dawson**, **M. Brewer**.

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Geological trace evidence: forensic and legal perspectives. **A. Keaney**, **A. Ruffell**, **J. McKinley**.

The geoforensic analysis of soils from footwear. **R.M. Morgan**, J. Freudiger-Bonzon, K.H. Nichols, T. Jellis, S. Dunkerley, P. Zelazowski, **P.A. Bull**.

Using soils and groundwater data to understand resistance surveys over a simulated clandestine grave. J.R. Jervis, **J.K. Pringle**, **J.P. Cassella**, G. Tuckwell.

Spatial thinking in search methodology: a case study of the 'No body murder enquiry', West of Ireland. **J. McKinley**, **A. Ruffell**, M. Harrison, **W. Meier-Augenstein**, H. Kemp, C. Graham, L. Barry.

Research in forensic taphonomy: a soil-based perspective. **M. Tibbett**, D.O. Carter.

Can temperature affect the release of ninhydrin-reactive nitrogen in gravesoil following the burial of a mammalian (*Rattus rattus*) cadaver? D.O. Carter, D. Yellowlees, **M. Tibbett.**

Taphonomic changes to the buried body in arid environments: an experimental case study in Peru. **R.C. Janaway**, **A.S. Wilson,** G.C. Diaz, S. Guillen.

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Discrimination of domestic garden soils using plant wax compounds as markers. **R.W. Mayes**, **L.M. Macdonald**, **J. Ross**, **L.A. Dawson**.

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Posters:

A geoforensic comparison of physical and chemical analysis of soils from the Plateau region of Switzerland. (3MB pdf) J. Freudiger-Bonzon, P. Bull, R. Morgan

Geoforensics and Information Management for crime Investigation (7.5 MB pdf) D. Miller, L.A. Dawson, K. Ritz and the GIMI Network

Geostatistics, Databases and GIS

Where Dunnit? (1 MB pdf) D. Donnelly, L.M. Macdonald, J. Ball and L.A. Dawson

Biological and Chemical Analytical Diagnostics

An Urban Investigation Using Alkaline Profiles for Land-Use Discrimination (770 KB pdf) V. Eaglesham, L.A. Dawson, L.M. Macdonald, A. Prieur, A. Morrisson, J. Ross and B. Mayes

Exploring the Forensic Potential of Novel Soil Profiling Methods (810 KB pdf) L.M. Macdonald, L.A. Dawson, R.W. Mayes, C.D. Campbell, B.S. Singh, J. Ross, M.J. Brewer, W. Towers, P. Bellamy, K. Ritz and C. Jordan

An Urban Investigation Using Colour for Land Use Discrimination (565 KB pdf) A. Prieur, L.A. Dawson, A. Morrisson, L.M. Macdonald and V. Eaglesham

Development of methodology for analysis of small soil samples for plant wax biomarkers enabling their use in forensic investigation (550 KB pdf) J. Ross, R.W. Mayes and L.A. Dawson

SoilFit: integration of soil fingerprinting techniques for forensic application. (1MB pdf) The SoilFit Team

Taphonomy

Manganese staining of medieval bone from Hulton Abbey. (0.3MB pdf) N. Lamont, N. Boothroyd, J. Cassella, R. Rushton, J. Pringle

Forensic characterisation of soil microbial communities in response to cadaver decomposition (110 KB pdf) K.R. Dias, R. Parkinson, J. Horswell, M. Tibbett

Does the soil microbial community adapt during the decomposition of skeletal muscle tissue? (1MB pdf) T. Luitingh, D. Carter, M. Tibbett

Future developments and opportunities:

-miniaturisation and applicability
-applicability of a range of soil markers as evidence of contact
-isotope analysis
-microbial indicators of place and time after death
-indicators of presence of body remains
-multiproxy indicators
-application of Bayes
-GIS models on web portals

2. We currently work with FSS, LGC Forensics, Orchid Cellmark, NPIA, SOCA, and directly with a range of police forces in the UK in England, Wales, Scotland and Ireland.

We worked with the FSS and NPIA as research partners on the Macaulay led projects:
(**http://www.macaulay.ac.uk/geoforensic/**
http://www.macaulay.ac.uk/soilfit). We are part of the 'Natural Justice' team of the FSS **(http://www.forensic.gov.uk/html/company/news/).** This is a group of experts in related disciplines (archaeology, entomology, soil science, diatoms) to provide a comprehensive environmental service.
We, at Macaulay Scientific Consulting/Macaulay Forensics, regularly advise and work with SPSA and individual forces in Scotland (recently with Lothian & Borders, Northern, Grampian, and Tayside).

3. Good examples of translation of research into practice are:
-Use of complementary analyses in a combined approach (i.e. mineralogy and organic characterisation) is a strong tool to link object and or person to place.
-Development of a soil sampling strategy and an associated soil sampling kit.
-Application of GIS search tools to search and recovery.

Examples of application in case work, for example, was with Derbyshire police in 2007 where as a result of scientific development in miniaturisation of analytical techniques, in a case of an aggravated burglary, analysis of soil linked trace amounts of soil on the footwear of three suspects to the house of the victims and led to their conviction. Also in 2009 working with Northern constabulary, soil maps and soil databases were used in the search and recovery of a missing person. In addition, two way transfer of material linked a spade to the body deposition site.

Examples of where there are still challenges are:
training to ensure correct taking of samples, taking of adequate control samples at the time of the offence. Difficult to get organised due to the halt on staff recruitment. I lecture and set practicals once a year for training of other forensic scientists and practitioners to increase awareness in this area.

3. Few opportunities exist at the moment due to funding shortages. Research has mainly to be carried out through student projects, preferably when networked and national, eg. **http://www.macaulay.ac.uk/forensics/soilfun/** (a network of student projects on urban soils and building a national urban soil database).

5. The important international networks in soil forensic science are;
http://www.macaulay.ac.uk/geoforensic/ and the *Geological Society of London Forensic Geoscience Group, established in 2006.*
Both have led onto an international group that has just been set up:
International Union of Geological Sciences (IUGS), an initiative to develop and promote Forensic Geology around the world (March 2011).

We would draw your attention also to the group in Australia http://www.clw.csiro.au/cafss/ being led by Prof Rob Fitzpatrick http://www.csiro.au/people/Rob.Fitzpatrick.html

This group have set an example of application of the understanding of soil to forensic case work by setting up a soil forensic specialist centre in that nation, Australia.

In addition, myself (along with Prof Fitzpatrick(CSIRO/CAFSS), Ms Marianne Stam (California Department of Justice, USA), Prof Karl Ritz (Cranfield University) and Prof David Miller (Macaulay Land Use Research Institute) have organised the Soil Forensic International Conference (SFI) now since 2005 (with three international meetings successfully held, Australia, Scotland, California). http://www.soilforensicsinternational.org/sfi2010.php

The fourth will be in The Hague as part of the European Forensic meeting http://www.eafs2012.eu/upload/0-announcement.pdf.

Submitter Details:

Dr Lorna Dawson
Principal Research Scientist
The Macaulay Institute

NATIONAL DNA DATABASE ETHICS GROUP

Dear Bernard,

Review of Research and Development in Forensic Science

I was delighted to see the announcement of your timely inquiry into Research and Development in Forensic Science. This will provide an opportunity for ensuring that the development of this area of scientific inquiry with significant implications for society is supported and varied ethical issues which arise are understood and kept at the forefront of the minds of those conducting and commissioning research.

The context for the review is timely for two reasons – the first is the changes to retention regime outlined in the Bill currently before Parliament reflect to some measure society's concerns about the use of the knowledge derived from one aspect of forensic science to which I will return later.

The second is the recently announced decision with respect to the future of the Forensic Science Service will change the future pattern of provision both of the provision of services to police forces and also may impact on the future developments of forensic science in this country. While there are obvious impacts in the short to medium term from this (with respect to service issues there is an obvious need to ensure that through this period of change proper standards are maintained and there is sufficient capacity to meet the needs of the police service and the Ethics Group will want to have re-assurance from the Regulator that standards are being and will be maintained) it underlines a deeper problem with respect to the conduct of research and development of forensic science.

The development of the knowledge base to underpin the application of science to forensic investigations is not generally seen as core business for the research councils and rather seen as possessing the characteristics of downstream research which is "near market" and would therefore usually be funded in and by the commercial marketplace. However while there is some appetite for innovative applications of scientific knowledge in specific criminal cases this may not be sufficient to ensure a coherent and systematic development of scientific knowledge. The removal of FSS from the landscape may well enhance this market failure.

As I indicated there is a concern within society as to the ethics and proportionality of some of the retention and use of DNA profiles. The Ethics Group clearly has a specific concern in this area. However that is not the only substantive ethical issue raised by this aspect of forensic science. The accuracy and reliability of the underlying techniques must be well understood as well as the population genetics which underpin the analyses needs to be considered in the light of the best available evidence. There is also an expectation that there should be the best possible use of all the sciences (consistent with the needs of a free society) to protect the safety and rights of individuals – for this to occur the gap between the cutting edge of science and

its application for forensic purposes needs to be narrowed - ignorance is not an ethical position.

The Ethics Group would be pleased to engage further with you as the outcomes of the review are worked through.

Yours sincerely,
Chris Hughes

NATIONAL PHYSICAL LABORATORY AND FORENSIC SCIENCE

1. Scale Scope and impact of the research and development carried out by forensic science providers and related organisations (in the public and private sector)

Introduction

The National Physical Laboratory (NPL) is the government owned UK National Measurement Institute, an internationally respected and independent centre of excellence in research, development and knowledge transfer in measurement and materials science. Serco operates NPL for BIS under a ten year Government Owned Contractor Operated (GOCO) contract.

Fig 1: The National Physical Laboratory

A full and detailed description of NPL's activities and capabilities can be found at the site: www.npl.co.uk .

The nature of NPL's measurement capability and experience means that our results are accurate and traceable to primary standards. Our results are robust, legally defensible values. We also provide the infrastructure which underpins the reference points for reliable quantitative evidence.

Scale of R&D

NPL has a research budget of about £50M pa, of which £45m pa is guaranteed through the GOCO contract overseen by National Measurement Office. A further £25M pa is generated through technical and knowledge services for other customers.

Our capability has a very wide scope, including physics, engineering, chemistry, biology, materials, mathematics, nuclear and sensing. Our work is also very multi-disciplinary.

We have a capital budget of £5M pa for investment in scientific facilities maintained at NPL.

We employ over 600 staff, including 500 technical and scientific experts, spanning a wide range of disciplines working in a purpose built 36,000m² laboratory housing many unique facilities.

These facilities provide the National Measurement System (NMS), which is the collective infrastructure of national facilities, expertise, knowledge services, science, research and legal framework for measurement in the UK. The NMS infrastructure underpins all measurements made for Forensic Science.

NPL makes this capability available to a very wide range of customers: government, business and academia. Our work for forensic science is predominantly the provision of internationally recognised reference standards to underpin the reliability of evidence presented to courts and R&D to develop or validate new forensic techniques.

Scope

We set out below a selection of our current research that is relevant to forensic science:

Analytical techniques

Fingerprint: non-contact chemical analysis using DESI (desorption electro-spray ionisation). DESI is a powerful new mass spectrometry technique that can identify pharmaceuticals, explosives, proteins and a range of biological materials at high speed and at ambient conditions.
Hair: a range of advanced optical microscopy techniques and also detailed surface chemical analysis.
Drugs Detection and Identification: research ongoing to provide accurate and instant in-field detection of drugs in saliva.
Glass & Paint (matching dispersed samples): optical and chemical analysis to match paint and glass samples visually and chemically.
Identification of radio-nuclides: analysis of radionuclide isotopic ratios for attribution of the source.

Dimensional techniques

Non-contact dimensional measurements: highly accurate, 3D stand-off measurements of crime scenes or evidence artefacts.
Tool Marks, Firearms and Munitions: including bullet matching and analysis – nano-scale surface measurements which can be used where standard matching techniques are not possible or are not conclusive.
Further high-resolution 3D microscopy and image software can also help remove the need for subjective opinions from matching or analysis work.
Crime Scene Mapping: Highly accurate and traceable 3D mapping of crime scenes using advanced laser metrology, GPS and systems integration. High accuracy can be achieved over long distances and micron accuracy of close up areas and objects.

Glass & Paint (matching dispersed samples): High accuracy measurement of samples and novel image analysis to provide evidence matching capability, including crime scene mapping. The dispersed samples can be analysed separately and links between them made with confidence.

Image analysis techniques

Forgery recognition: Optical Measurement and Digital Image Correlation (DIC) for use in analyzing documents, counterfeits and forgeries.
High-resolution 3D microscopy and image software for matching and analytical work, removing the need for subjective assessments.

Environmental monitoring techniques

Trace analysis: NPL has developed unique facilities for environmental monitoring that are applicable for the policing of environmental regulations.

Impact

We set out below some examples of the impact of NPL R&D on forensic science.

Breath-analysers: NPL carried out the R&D that led to the introduction of more reliable gas standards, rather than liquid standards, for the calibration of alcohol breath analysers at police stations, and carried out type testing of the instruments now in use.

Biometrics: NPL has independently evaluated the reliability of identification systems and provided consultancy on biometrics to the Home Office.

Forgery / Counterfeit / Distinguishing features of documents: We have the capability to distinguish between real and counterfeit documents and can detect distinguishing marks and traces to be able to match documents to printers. NPL's advanced work in optical measurement and Digital Image Correlation has been sought by the Danish government to help identify forged banknotes.

Reliability of evidence: NPL underpins the traceability chain, and the validation of analytical techniques to ensure that courts accept the evidence chain for analytical samples. This requires ongoing R&D as new forensic techniques are introduced.

Consultancy

NPL successfully works with a broad spectrum of the forensics community including Police Forces, APCO and NPIA on a variety of problem solving consultancy projects where physics, science, detection and measurement are important.

2. The extent, and the way in which, forensic science practice assesses the relevance of, and accesses, the latest advances in technologies and techniques.

NPL formulates the R&D programmes for the NMS for the NMO. The process includes a scan of advances in technologies and the changing requirements of users of the NMS infrastructure. The forensic science community are part of the consultation.

3. The scale and scope of forensic science research undertaken in academia and it links with forensic science practice.

NPL collaborates with more than 80 academic organisations, selecting the most expert university group for each R&D project. It also has strategic partnerships with three universities and with the EPSRC.

An example of how we work with academia in R&D for forensic science is in surface analysis where we work closely with Kings College London to develop the DESI technique for fingerprint chemical analysis, and explosive and narcotics detection.

4. The current and potential contribution of international research networks to UK forensics science research and practice.

NPL's R&D for the NMS is strongly linked into an international research network for metrology. This includes a €400M European Metrology Research Programme (EMRP) funded by the EU to develop a European Research Area for metrology. Most National Measurement Institutes in Europe participate in the EMRP.

NATIONAL POLICING IMPROVEMENT AGENCY (NPIA)

INTRODUCTION

For the purposes of this response forensic science is:

> 'Any scientific and technical knowledge that is applied to the investigation of crime and the evaluation of evidence to assist courts in resolving questions of fact in court'.

The police use forensic science to protect the public. To do this, forensic science needs to deliver in 3 key areas:

- Identification - including identifying and eliminating suspects and victims (of crime and disasters)
- Investigation - answering 3 main questions: Has a crime been committed? Who is responsible? Is there enough evidence to charge and prosecute?
- Public reassurance - the public expect forensic science to provide expert impartial evidence that contributes to the delivery of an effective and transparent criminal justice system. The role of forensic science can be important in reassuring the public in high profile major crime cases and in more routine police work such as responding to burglaries and other volume crime.

The police forensics market is estimated to be between £370-390 million in revenue spent per annum.

The impact of forensic science is not just high in financial terms – the social and political costs of not getting it right are substantial, particularly when public confidence is undermined by offenders not brought to justice or miscarriages of justice.

To facilitate the use of forensic science in protecting the public, research and development is essential to ensure the continued availability of a high quality, efficient and effective forensic capability for the criminal justice system. Historically this research and development was undertaken by a range of organisations including the private sector, Government owned laboratories and academia.

In February 2011, the Home Office commissioned a review of research and development in forensic science. This review will make recommendations to Ministers with advice on the current and likely future landscape in this area.

The aim of this paper is to set out the NPIA's understanding of current provision of forensic research and development, what works well and where there are gaps. The paper also offers ideas about how these gaps might be addressed ensure forensic science services are effective and economical and enhance the UK's criminal justice service.

The paper considers the following issues:

1. The challenges facing Government and others;
2. Progress to date;
3. The future landscape, risks and opportunities.

Through answering these questions the paper will:

- Identify deficiencies in the current research and development provision and outline opportunities for significantly improving forensic research and development within existing funding regimes;
- Provide an overview of the NPIA's role and how it supports forensic research and development on behalf of the Police Service;
- Give examples of good working practice that could be exploited further to benefit the present situation.

1) The Challenges Facing Government and Others

The Criminal Justice System on its own is a relatively small user of scientific research and development. However, within that system the Police Service has a clear requirement for effective and economic forensic applications, especially within the field of DNA. The precision and reliability of those applications is of high concern to the public, as evidenced by the continued parliamentary and media interest in the police use of forensics.

The Defence and Health sectors are much larger users of scientific research and development than the criminal justice sector. Most of this R&D capacity is not specifically focussed on forensic science, although some is transferrable into the operational policing environment. These developments are often utilising the same analytical techniques but in a different context. The military uses biometric data for intelligence, and the Health sector uses DNA in medical research. Within the policing environment both biometric data and DNA are used for evidential purposes.

A) Investment Focus

Research and Development (R&D) that assists the application of forensic science in the criminal justice system is undertaken by multiple Government departments, public bodies, private companies and academic institutions.

Most forensic R&D is funded by public money provided by a range of Government departments, including the Ministry of Defence and the Home Office and the funding councils.

It is difficult to get a clear picture of exactly how much funding is available and what it is spent on, because of the involvement of so many bodies and because forensic R&D may be one strand of research activity reported as part of larger programmes of activity on topics such as crime reduction or global security.
Despite the difficulty in being able to state exactly what funding is spent on forensic R&D, we do know that there is funding and research capability that could possibly be further exploited. For example, the Ministry of Defence employs 3,700 staff with a budget of almost £600m at the Defence Science Technology Laboratory (DSTL). Clearly, they have a wide remit and responsibilities for scientific development for their sector but they share an interest in the role and reliability of forensic science.

The Home Office Scientific Development Branch (now Centre for Applied Science and Technology (CAST) also dedicates a small resource to forensic research and development (although with a much smaller budget than DSTL).

There is additional research capability within the NHS Innovations Programmes. These are a network of regionally linked departments that develop and progress innovation in medicine on behalf of the NHS, which includes, product development through to commercial implementation, funded by the private sector[17].

There are also significant international funding opportunities in this area including European Union Framework Programme 7[18] (FP7) initiatives that bring together international partners from across the EU to develop innovative solutions to Government related problems.[19] There is in excess of €40 billion available for collaborative projects in science and technology within the FP7. At present opportunities are not being exploited to derive the maximum benefit from the funding which is available.

The embedding of forensic R&D in research on other, broader issues may mean it takes place inconsistently which risks forensic users continuing to utilise out of date applications or knowledge with the associated risk of poorer outcomes for the public and resource waste.

A contributing challenge is the degree to which the forensic R&D that does take place addresses the capability requirements of forensics users.

The nationally available funds tend to be directed at specific national policies and associated operational requirements (as is the case with the Defence Science and Technology Laboratories) or the broad range of scientific

[17] http://www.innovations.nhs.uk/
[18] http://cordis.europa.eu/fp7/home_en.html
[19] http://www.businesslink.gov.uk/bdotg/action/layer?topicId=1073858790

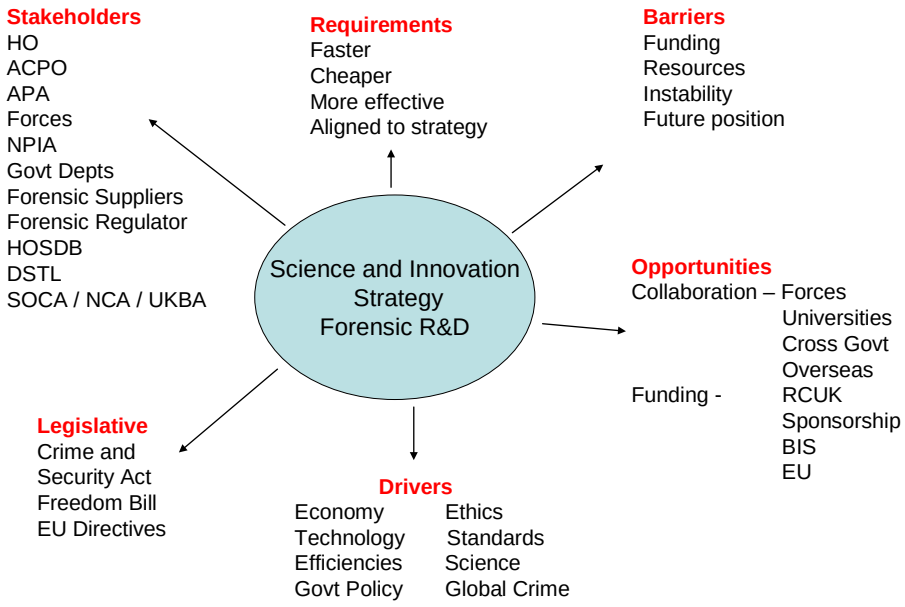
applications that impact on society, such as the case with the Engineering and Physical Sciences Research Council. This hierarchy of focus can mean that the R&D that does take place is not aligned to the required needs.

B) Lack of Coordination

Uncoordinated involvement of so many Government departments in funding Forensic R & D, the absence of direct links between government departments and practitioners applying forensic science and the poor alignment of research and service needs work against maximising the outcomes of that research for the public.

The current organisation and management of forensic science and associated R&D does not facilitate effective exploitation of potential applications of forensic science research. This is surprising given that many of the forensic science techniques that are currently used in policing have evolved from their use elsewhere. For example, neither DNA nor fingerprinting originated in policing. Instead DNA came from the health environment and the use of fingerprints dates back to the colonisation of India where the fingerprint was used as a personal identifier.

The chart below shows the complexities of the landscape for forensic research and development:



The complex delivery landscape in this field includes the 43 Home Office police forces, the Association of Chief Police Officers (ACPO), NPIA, Serious Organised Crime Agency (SOCA), Home Office (including HOSDB/CAST) and the academic and private sectors. The challenge is exacerbated by the fact that each player tends to work alone creating isolated research silos. For example, for historical reasons HOSDB has taken the lead on research in the fingerprint space, while the NPIA has led on DNA-related research.

The Science and Innovation Strategies of the Home Office[20] and the Police Service[21] recognise the importance of a coordinated approach to addressing R&D requirements in forensic science, as part of a plan of work to improve the use of science and innovation in policing.

Again, traditionally, research focus has tended to be on the contribution of physical science but the development of the Police Science and Innovation Strategy, its sibling Knowledge Action Plan and the on-going debate about privacy and security point to the need for a multi-disciplinary approach to problem solving and ensuring that forensic science is acceptable to the public as well as effective and economic. An example of this is the need to assess the social implications of developments in physical science (e.g., DNA) and technology (e.g., CCTV).

Until recently, policing did not have an agreed approach to capturing and articulating its research and development needs, including those within forensic science.

A lack of a shared understanding has prevented the service from effectively voicing its needs and a failure to articulate and communicate police research and development needs to those who could address them. The result is duplicated efforts and gaps in meeting real world challenges. There is no real understanding of current investment or of the return on that investment. Beyond policing and criminal justice there are missed opportunities to share learning and innovation across sectors.

2) Progress to date

The police service is undertaking a range of activity to maximise the finite resources available for research and development across forensic science and enhance the coordination of activity across and outside of government, to ensure it has the biggest impact in meeting the key challenges facing the service.

A) Science and Innovation Strategy

As part of a commitment to the Home Office Science and Innovation Strategy, the Police Science and Innovation Strategy was published in March 2010. Its aim was to meet the challenge outlined above.

The Strategy aims to:

- Deliver improved police capabilities year on year;
- Ensure that policing decisions are supported by robust knowledge about the impact and effectiveness of different approaches; and

[20] Home Office (2009) Science and Innovation Strategy 2009-2012
[21] ACPO, APA, Home Office and NPIA (2010) Science and Innovation in the Police Service 2010-13

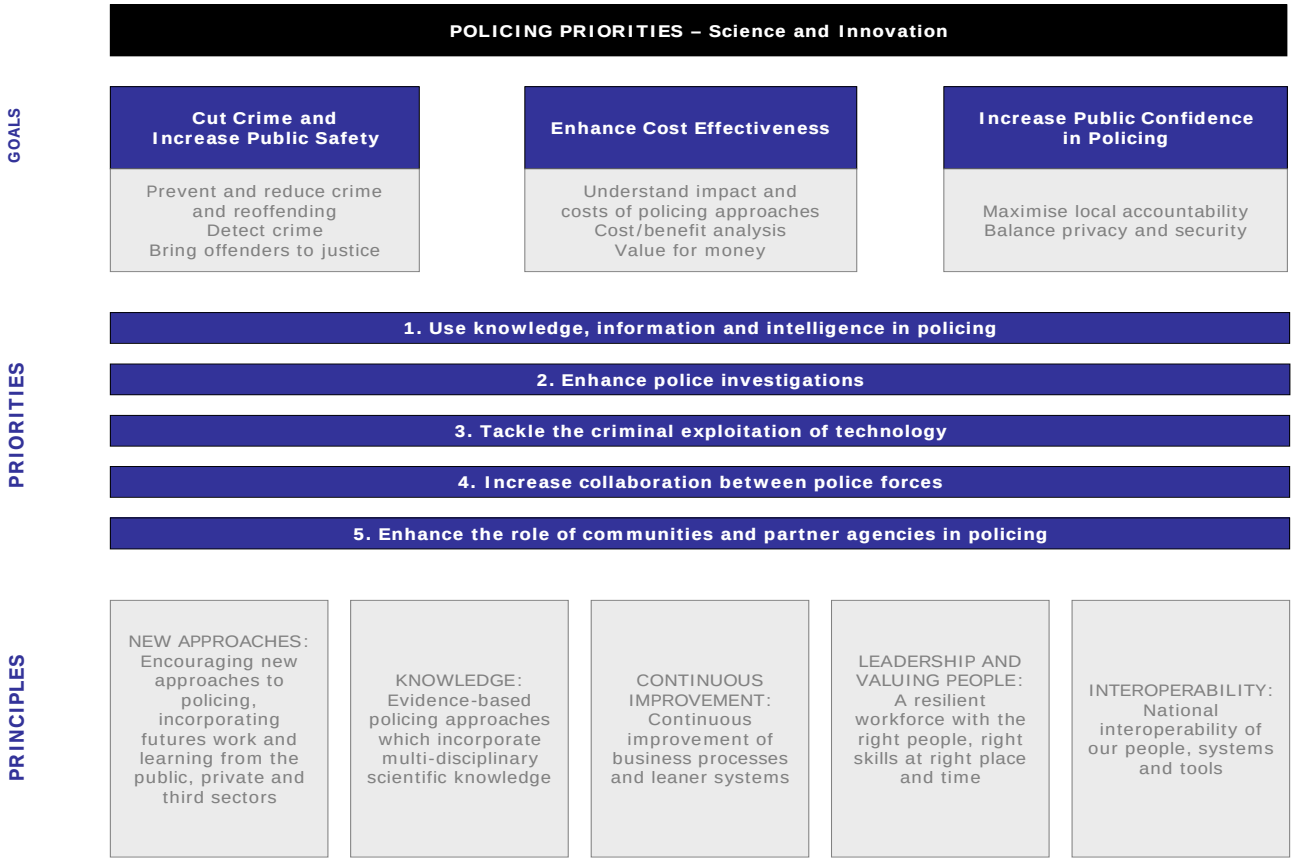
- Harness radical long term scientific developments.

The delivery of these goals is based on the 3 key principles for action;

- **Coordination** – where there are clear priorities for police science and innovation and where the different activities of the organisations involved align together to have maximum impact;
- **Collaboration** – where research and development work engages police officers and the public; and where specialists from different sectors and disciplines work together, encouraging innovation to transfer from one area to another;
- **Challenge** – where investment in innovation is targeted to where it will deliver the strongest benefits; where these are realised faster than in the past; and where we challenge others to help address the most pressing police needs of the future, in order to better protect the public.

B) Framework of policing priorities for Research and Development

As one of the commitments in the strategy the NPIA, in partnership with the Police Service was asked to develop a framework of priorities (see framework below) for police science R&D. Developing priorities of the service ensures that research and development can be focused on the areas that are most important to policing. Without this clear articulation, providers of forensic science R&D lack sufficient information to guide their focus for future research. This framework (below) was agreed by ACPO in September 2010.



To enable these priorities to drive the targeting of scientific investment, the NPIA (in consultation with ACPO business areas, police forces and other stakeholders, including the Home Office) are establishing a more detailed list of the capability and knowledge gaps that need to be addressed. The current Forensic R&D projects being undertaken by the NPIA and the Home Office are also being mapped against these capability and knowledge gaps. This process will provide an overview of where current Forensic R&D efforts are being directed against policing priorities. In total, the Home Office and the NPIA mapped almost 300 projects against the gaps, with around half of these projects (147) relating to the general area of forensic science. Definitional issues make it difficult to get a precise figure for the amount of projects that are related solely to Forensic Science research but from the information collected there are only 35 such projects currently mapped directly to pure forensic R&D. The majority of these projects (just under 20) are taking place under the 'Enhancing police investigations priority' and focus on Fingerprint, Biometrics and DNA related research. The other projects can be defined as activities that would be regarded as business as usual that support the science and innovation strategy, eg, delivery of Ident 1 and National DNA Database services.

C) Police Service Knowledge Action Plan

The Action Plan aims to improve the use of knowledge to ensure that decisions for the Police Service are based on evidence of what works. Two areas, in particular, are supporting the improved coordination of Forensic Science R&D: the Police Online Knowledge Area (POLKA) and the Research Map. POLKA has established a number of online communities that provide mechanisms for improving knowledge sharing in policing, including one for Forensic Science. It is hosted on the PNN network to enable secure sharing of good practice across the Police Service.

The NPIA is engaging with the academic community to create a publicly available policing research map, which will allow academic researchers to record details of their policing projects and map them against the five policing priorities. The map will enable researchers to promote and build on their current research, focus their efforts on filling gaps in capability or knowledge and collaborate with others. All areas of policing research will be covered, including forensic science. A first version of the online collection and dissemination of information will go live in April 2011.

The Action Plan also recognises that forensic science provides an opportunity to develop a collaborative approach to the creation and sharing of knowledge through initiatives such as the North East Universities Forensic Network.

Case Study – North East Universities Forensic Network

The NPIA is working with a number of regional universities in the North East to develop an academic forensic network.

The need for greater visibility of policing priorities in academia has been an issue for some years. Now that the Police Service has developed a strategy for the use of science and identified its priorities, these and detailed knowledge and capability gaps need to be communicated to industry and academia.
The three universities in the north east with specific links to forensic science are Northumbria, Sunderland and Teesside. Collectively they cover laboratory analysis and crime scene and forensic technologies. However, they also have access to the wider range of subjects offered across the universities, from engineering and health through to business and technology.

The NPIA facilitates this Network and is working with academic institutions to identify where the gaps exist and how the universities can utilise their broad range of capabilities to bring innovative solutions to operational problems.
The Terms of Reference for the group have been agreed. These focus on how the universities can support the science strategy through collaborative research and bids for funding focussed on applied areas of scientific research. This initiative follows the R&D process model with greater involvement of academia in delivering holistic solutions to policing problems.

D) Strengthened Governance

In recent years ACPO and NPIA governance of police forensics has strengthened. It has moved away from forensic evidence space silos, to tackle cross-cutting issues through a managed programme of work.

The ACPO Forensic Portfolio is led by Chief Constable (CC) Sims of West Midlands Police. CC Sims also oversees a number of other ACPO portfolio holders on Performance and Standards, Business Change, DNA Strategy, Forensic Databases, Pathology, Forensic Procurement and Forensic Science and Innovation.

The ACPO subgroup on Forensic Science and Innovation includes representation from the NPIA, SOCA, HOSDB, the Crown Prosecution Service (CPS), and the Forensic Regulator. It aims to determine the policing requirements from a forensic perspective and transfer these into an operational and functional solution. Its activities include;

- Liaison with and advice to academic institutions;
- Guidance on the future direction of research activity in order to align with policing priorities;
- Identifying opportunities from research activity that can be utilised in the operational policing environment.

There are examples of this group driving innovation to fruition by:

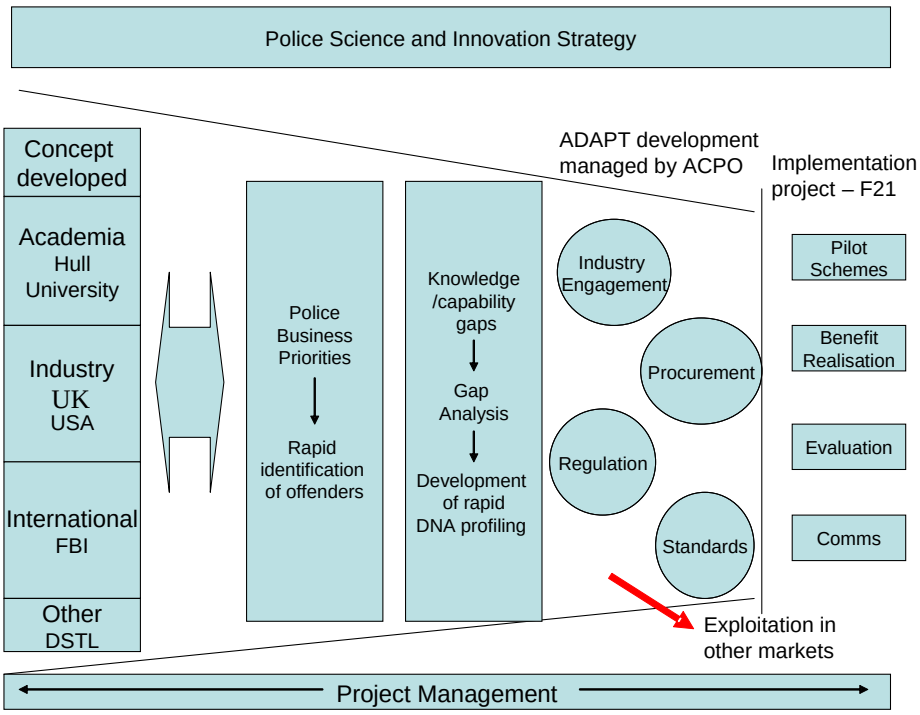
- Providing a single customer voice and channel to the innovation market;
- Setting clear CJS requirements at the start of the process;
- Reviewing and commissioning research and development; and
- Shortening the time to delivery.

Case Study – Rapid DNA Technology, ADAPT

The business requirement to identify persons more quickly has always been at the forefront of investigation and the rapid development of technology has now enabled this capability gap to be explored further. The ability to be able to process real time DNA samples at the crime scene or custody in an hour, without having to send samples to a forensic laboratory will revolutionise the way DNA is used in a criminal context.

This concept was recognised and circulated to the open market as a policing problem inviting potential solutions resulting in responses in four suppliers being selected from many to develop the technology to the point where it could be fully evaluated in the operational environment. Operational pilot's will be deployed in forces imminently to evaluate the operational benefits of the concept that will result in potentially national availability. Initial business modelling suggests that there will be significant financial savings for forces who adopt the technology.

The diagram below shows how the forensic science research and development model is applied in the form of an innovation funnel. Using the ADAPT DNA project as an exemplar, the left side of the model displays the key players in terms of providing research and development activities. The next stage filters these activities to establish if they support the science and innovation strategy and policing priorities, through to those projects that actually meet the requirements and are converted into a formal ACPO project, and finally through to implementation in the operational environment. The model operates on diminishing returns clearly demonstrating that not all projects initiated make it through to implementation.



Case Study – Innovation to Implementation
Remote Transmission of Crime Scene Marks (RTOCSM)

A business requirement was identified by ACPO to reduce the time taken for processing crime scene marks from an average of 17days to a more responsive timescale. The Forensics 21 programme was commissioned by ACPO to research and implement a workable solution.

Through links to universities, industry (funding from Vodafone) and academia, the solution of Remote Transmission of Crime Scene Marks (RTOCSM) was developed under ACPO guidance in conjunction with Lincolnshire Police. The solution was refined to enable national implementation into police forces. This reduced the average time for identifying crime scene marks from 17 to 2 days.

In the operational environment, this technology was utilised by Sussex Police in an aggravated burglary case where a security guard was attacked and bound while the offenders stole 100 laptop computers. The finger marks recovered from the scene were transmitted using this technology. An

identification was passed to the investigating officer within 75mins resulting in a quick arrest and the recovery of the stolen property. This approach has now been embedded into specialist forensic training delivered by the NPIA and is standard practice in many police forces.

This example followed the process of identifying a business need, working with industry and academia, carrying out a gap analysis with eventual implementation into police forces.

3) Future Landscape, Risks and Opportunities

The reform of the policing landscape suggests that current NPIA functions will be divided between different organisations. Planning for the reformed landscape needs to include provision for a coordinating function to articulate and communicate a police voice to the providers of R&D. Such a function includes maintaining a clear oversight of ongoing and planned R&D across government, academia and beyond. Given the likelihood of an increased role for commercial providers in filling R&D gaps, consideration needs to be given to how collaboration can be encouraged or required, particularly when public money is involved.

The challenge will be to ensure that gains made in strengthening central coordination and governance in this area are not lost. This will include:

- Managing a framework of policing priorities, including detailed knowledge and capability gaps;
- Communicating these to providers of research and development in the public, academic and private sectors;
- Aligning planned activity to police needs to ensure that investment is focussed on meeting operational requirements;
- Effective commissioning to make the best use of resources;
- Linking police needs to the wider criminal justice and government agendas;
- Aligning learning and training programmes to forensic research and development.

Delivery will require a focus on the principles set out in the Science and Innovation Strategy: Coordination, Collaboration and Challenge.

Coordination is required to:

- Improve knowledge of national investment in forensics related research and development;
- Co-ordinate research and development activity across a number of other government agencies and departments, such as the Ministry of Justice, Defence and Health, to maximise the diffusion of benefits across sectors an reduce duplication of effort and funding; and
- Maximise the potential for the UK to access European and international funding to enhance its forensic research base.

There needs to be a central mechanism that has national oversight of research and development activities to ensure that activities are steered towards the requirements of the science and innovation strategy.

At the present moment, the NPIA carry out this function to a certain extent, but with the remit extended to provide oversight at the strategic level and working in conjunction with ACPO and the Home Office, the situation could be greatly improved.
Collaboration should be one of the central benefits of taking a coordinated approach by ensuring that available resources for Forensic Science R&D are used efficiently and effectively.

- **Home Office** – there is an opportunity to make more of the science and development activities already taking place across the Home Office group and in particular within the Centre for Applied Science and Technology (previously HOSDB). Home Office departments, for example, UK Borders Agency and the Office for Security and Counter Terrorism already make use of science in their work but could achieve more with improved and more coordinated access to specialist resources across departments. Examples of these shared beneficial scientific applications are biometrics, identification, and forensic investigative techniques. The development of a central forensic board within the Home Office could enhance opportunities for operational and research collaboration across the group.

  There is also scope for ACPO to continue to work with the Home Office to articulate the police service's requirements and ensure these are aligned with government priorities for Forensic Science R&D so that providers, including HOSDB, have clear and agreed priorities for focusing their future research efforts.

- **Pan Government Collaboration -** There are significant opportunities for collaborative research and development activity across a number of other government agencies and departments, in particular, Ministry of Justice, Defence and Health where funding and capability has a far wider reach than the Home Office in isolation. Probably the most commonality occurs with the MOD and their research capabilities through DSTL, who have significant resources dedicated to the development of scientific solutions to the defence and security sector. Whilst the main remit for science and technology developed by DSTL is operating within a different context to conventional policing, many of the solutions are potentially transferrable. Some examples of this in particular, are within the forensic arena developing fingerprints from articles and the use of DNA as an intelligence and investigative tool. The police through the NPIA are developing rapid DNA technology at a parallel time but with little collaboration at this stage, mainly due to the fact that both NPIA and DSTL were unaware that they were operating in these areas.

  The development of a Memorandum of Understanding between the two agencies may assist in bringing together collaborative approaches to forensic issues that could be jointly commissioned and shared amongst

government agencies subject to the sensitivities and nature of the issue being considered.

Another area where there is significant research capability is through the NHS Innovations Programmes which is a network of regional linked departments that develop and progress innovation in medicine on behalf of the NHS. This includes product development through to commercial implementation funded by the private sector[22].

Challenge is required to ensure that investment in research and development is maximised and targeted towards the delivery of the strongest benefits for the public. A central co-ordination unit could provide the key to sourcing appropriate levels of finance from funding bodies.

- **Technology Innovation Centres (TIC's) -** In October 2010 it was announced by the Government that over £200m will be invested in a network of elite technology and innovation centres, to be established and overseen by the Technology Strategy Board. Centres of excellence can create a critical mass for business and research innovation in a specific area and sector by focusing on a specific technology where there is a potentially large global market and a significant UK capability. These centres will be an important part of the UK's innovation system. They will allow businesses to access equipment and expertise that would otherwise be out of reach, as well as conducting their own in-house R&D. They will also help businesses access new funding streams and point them towards the potential of emerging technologies. The new investment will further bridge the gap between universities and businesses, helping to commercialise the outputs of Britain's world-class research base. The centres will also complement and link with the other programmes which the Technology Strategy Board already manages to promote collaboration between universities and business, and to drive innovation and the commercialisation of new technology and ideas. Whilst the first tranche of TIC's are in the process of being considered, there is a model in place for the potential development for a TIC with a policing theme that could attract government funding and assist in furthering the policing requirements[23].

- **Academic Research -** The issues regarding access to academic research funding have already been well documented within this response, however, there also needs to be a structured approach to encouraging the academic community to addressing the priorities of government and the capability requirements of the service. Involving policing, including as partners, in the initial bid process would help research teams ensure research findings can be applied operationally and that they address practical priorities. This should not, however, stifle the development of

[22] http://www.innovations.nhs.uk/

[23] http://www.innovateuk.org/_assets/pdf/corporate-publications/prospectus%20v10final.pdf

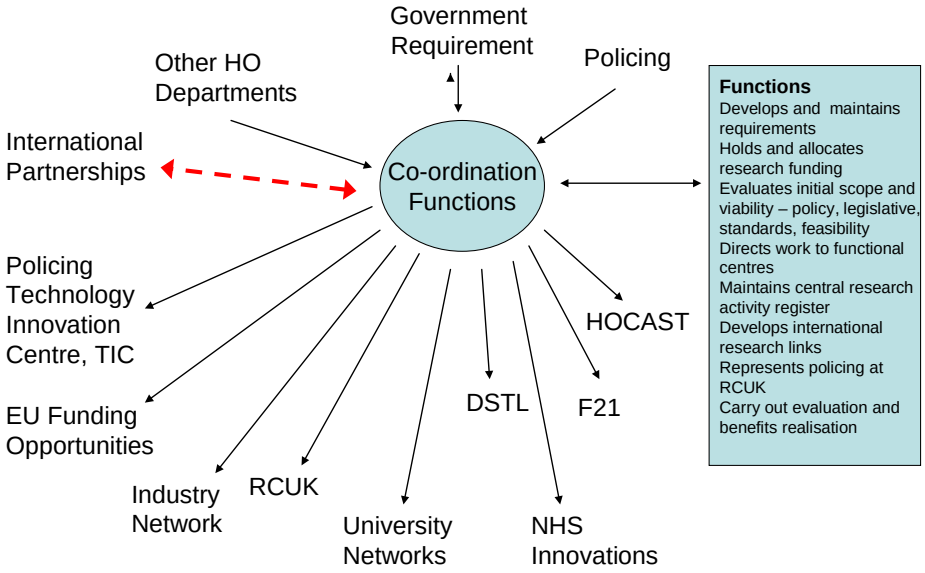
pioneering ‘blue sky’ research and innovative thinking, but there needs to be a balance between the exploratory and the practical to bring better fiscal exploitation in this area. There are a number of considerations that could potentially address the issues:

- Ensure that there is representation from policing on the decision making panels to provide a user requirement when there is a policing or public safety research bid. This would provide the reality check for the viability and potential application in operational policing.
- Top slice funding from the research councils and dedicate this towards forensic science research and development that could be subject to a similar bidding method to the existing process. The funding would remain within the university system as it does now, but would have more impact in the operational environment.
- Remove an element of funding from the research councils and dedicate this to a network of post doctoral research across a range of universities, and provide them with specific policing problems linked into the agreed priorities. This could be co-ordinated from a central point with specific direction from ACPO and policing. Again, the funding would remain in the university system but more directly linked to the government requirements.

Across the landscape of coordinated R&D there is a need to fundamentally review the processes for effectively exploiting ideas generated that are fit for other markets beyond policing for the ultimate benefit of policing, as per modern innovation models[24]. For example the rapid profiling of DNA has many applications in other sectors such as health, defence and paternity testing for example and IP generated needs to fully leveraged.

[24] The Era of Open Innovation
H. Chesbrough, MIT Sloan Management Review, Spring 2003, pp. 31-41.

The graphic illustrates the functions of co-ordination:



Summary

Existing forensic research and development activity goes some way towards ensuring that forensic science contributes to the delivery of an effective and transparent criminal justice system, identification of suspects and victims (of crime and disasters) and to investigation of crime.

However, more could be done to ensure that forensic R&D is focused on priority capability and knowledge gaps in the use of forensic science and that the criminal justice sector can exploit innovation in other fields and techniques from policing can be exported to other sectors.

Therefore, the future requirements are for the:

- Strategic planning and light-touch co-ordination of forensic research and development activities across universities and other Government departments;
- Direct involvement of users of forensic science in prioritising R&D investment, and in refreshing the R&D focus;
- Mechanisms for sharing knowledge about effective and efficient science amongst practitioners and researchers;
- Brokerage of research and development partnerships with users of science that enable internationally funding opportunities to be realised;
- Engagement with international partners will ensure that the UK will remain at the forefront of forensic science research and development.

The NPIA recognises that Forensic Pathology was excluded from the scope of the review. However, we remain concerned at the lack of focussed investment for R&D in this significantly challenging area of business.

NATURAL HISTORY MUSEUM

Natural History Museum response to Questions for Researchers
12th May 2011

1. What work relevant to forensic science is being done in your group/university and what are the opportunities for the future?

Forensic science research and development at the Natural History Museum focuses on forensic entomology, but we are developing the application of other areas of our expertise relevant to forensic work, in particular forensic anthropology (www.nhm.ac.uk/forensics). Other opportunities for us exist in the field of diatom analysis, forensic botany and soil and mineral analysis.

2. What previous and current research partnerships do you have with forensic science providers, police forces, the National Policing Improvement Agency, etc.?

Our senior casework staff are registered with the NPIA database of experts, enabling them to be contacted directly by police forces for casework. In addition we have, or are in the final stages of developing, contracts to provide a forensic entomology input to the casework of the Forensic Science Service, LGC Forensics and Cellmark Forensics.

3. Can you give good examples in the forensic science field of translation of research into practice, and also any examples where this has been difficult or problematic?

Much of our work in entomology concerns researching the development rates of flies of forensic importance, especially neglected species, to help in estimating time of death in cases of suspicious or untimely death. In the past some cases, including high profile murders, have been poorly investigated from an entomological perspective due to a lack of data. Following a research programme funded by the Public Sector Research Exploitation Fund Fourth Round (PSRE-4), we are now approaching a position where we can deal with most blowfly species encountered. Data is made available through research publications (e.g. Donovan, S.E., Hall, M.J.R., Turner, B.D. and Moncrieff, C.B. [2006]. Larval growth rates of the blowfly, *Calliphora vicina*, over a range of temperatures. *Medical and Veterinary Entomology,* **20**, 1-9) or synthesised within protocol papers (e.g. Hall, M.J.R., Brown, T., Jones, P. and Clark, D. [2008]. Forensic Sciences. Pp 463-497 in, *The Scientific Investigation of Mass Graves: towards protocols and standard operating procedures*, Cox, M., Flavel, A., Hanson, I., Laver, J. and Wessling, R. (Eds.), Cambridge University Press, USA, xxx + 562 pp.). Our most recent data is in the process of being prepared for publication by peer-review, but has already been applied with success in casework enabling us to provide more accurate analyses than previously.

In addition to work on live cultures, we have just begun a project to specimen level database information from insects of forensic importance in our National

Insect Collections, starting with blowflies. This is already providing valuable information on seasonality and distribution that can be readily applied in casework to identify what species are likely to be encountered at a scene. Other areas of our research that use new technology (e.g. infra-red thermography and computer tomography) to support our investigations are in an earlier stage of development for application to casework. There could be constraints to the routine and widely applied use of CT techniques because of the limited availability of equipment.

4. What do you see as the opportunities for, and the barriers to, the funding of research relevant to forensic science?

We are just approaching a period when we will be seeking new funding to extend our research studies so will be in a better position to answer this question soon. However, one potential problem is that UK research council funding could be difficult to obtain for research that is perceived as not novel in kind or "blue skies", even if it is providing novel data by applying proven techniques to previously unstudied species. The development of databases of information on a wide range of insect species is vital to furthering the application of forensic entomology techniques.

5. What are the important international networks and how useful are they? Do you have any specific international collaborations you would wish to draw to our attention?

There are, of course, a number of important international societies in the field of general forensic science that provide networking opportunities. Of most value in the specific field of forensic entomology is the European Association for Forensic Entomology (http://www.eafe.org/). EAFE has an annual meeting for exchange of research information and provides a framework within which to discuss, develop and agree protocols for the application of the science (e.g. Amendt, J., Campobasso, C., Gaudry, E., Reiter, C., LeBlanc, H. and Hall, M. [2007]. Best practice in forensic entomology – standards and guidelines. *International Journal of Legal Medicine*, **121**, 90-104).
An increasing degree of international research collaborations is resulting from the EAFE networking and a number of partners from EAFE have just submitted a bid to the EC to establish an international training network in forensic entomology.

6. Are there any other issues relevant to our terms of reference that you would wish to comment on?

No.

PROSPECT

This submission has been drawn up on the basis of consultation with Prospect's members in the FSS, and is based on their first-hand knowledge and experience.

Q1. What work relevant to forensic science is being done in your group/university and what are the opportunities for the future?

2. Within the length limitations for submissions to this review it is possible only to provide a brief overview of the FSS' R&D work. FSS is internationally acknowledged as the initiator of all the significant advances in forensic DNA profiling [1] and continues to play a leading role through being the first to develop the new genetic tests required by EU legislation for introduction into the NDNAD before 30 November 2011 [2-4] in order to improve compatibility with other national databases. This work formed the basis of the first commercially available kit meeting the international requirements. FSS has also developed award-winning database storage and searching software [5] compatible with the new international standards which greatly increases speed of DNA interpretation and significantly improves match rates. In response to police requirements for faster turn-around-times, new robotic lines have been developed delivering 30% efficiency gains in the laboratory environment, which is being shared with international contacts in Abu Dhabi, and an instrument which offers a full 16 locus (future NDNAD) compatible profile within 2.5 hours within a custody suite [6, 7]. With an eye on the rapid advances in genomic technology and databases work and collaborations were initiated to develop the next generation of DNA tests, an area requiring clear strategic leadership for the UK to reap the full benefits.

3. FSS' interpretation group is developing robust probabilistic methods for the analysis of many evidence types including fingerprint identification that will address the concerns raised by the Scottish fingerprint enquiry, whilst new software will greatly increase the speed and efficiency of comparison. Methods of linking evidence from different forensic evidence types offer both faster intelligence analysis and improved presentation within the courts. Ongoing work within operational delivery units has seen the introduction of new methods and equipment such as DART-MS, the unique capabilities of which within Europe are being exploited in support of national security [8] Teams working in operations are also utilising their vast databases and accumulated experience in other disciplines to advance forensic knowledge through national and international networks [9].

Q2. What previous and current research partnerships do you have with forensic science providers, police forces, the National Policing Improvement Agency, etc.?

4. Researchers within the FSS remain keen to collaborate with academia within the UK and abroad. With support from the research councils some early-stage technologies have been explored, including multispectral imaging and fluorescence-labelled antibodies for the detection of body fluids and fingerprints. Peptidomics shows possibilities in providing information about an

unknown suspect, and the use of nanotechnology can trap DNA from an offender, allowing improved DNA profiling to be performed. Other work has explored the link between surnames and Y-chromosome, the use of Mass-Spec for DNA profiling, and development of microfluidics for DNA analysis. FSS currently support 3 students in academia through CASE awards. FSS has collaborated with Hamilton in developing the most sophisticated forensic robotic line in the UK and possibly the world, providing innovative technology that will now be used internationally. Direct communication with police forces has been restricted by NPIA's role as intermediary.

Q3. Can you give good examples in the forensic science field of translation of research into practice, and also any examples where this has been difficult or problematic?

5 None of the outcomes of research council-funded research have been successfully implemented into casework. This is largely because of a gap in funding/support between basic research, which provides the proof of principle, and the development of a robust, fit for purpose process that is required for forensic application.

6. The current fragmented system in which database policy, maintenance and innovation are the responsibilities of separate organisations has resulted in lengthy delays in the adoption of improved software for the NDNAD and its ability to attain internationally acceptable standards for data comparison. This is in stark contrast with the situation when FSS both developed and managed the NDNAD. Inability to access NPIA-held databases has stifled research and investigation of anomalous results. If following the dissolution of NPIA the databases and R&D functions were to be united, a slimmer and more efficient system attuned to continuous and robust improvement could be achieved.

7. The benefits of co-locating researchers and practitioners include free exchange of information from concept to case-hardening. Development work utilises equivalent facilities and equipment to ensure seamless migration into casework. FSS's R&D has been performed in an accredited environment to high standards to ensure that it is subsequently robust to challenges such as the defence of LCN in the Appeals Court.

Q4. What do you see as the opportunities for, and the barriers to, the funding of research relevant to forensic science?

8. There is a need for centrally funded forensic R&D budget to support strategic development to regain and maintain UK leadership whilst providing a stable environment in which an experienced specialist group can retain key skills and knowledge for the broader benefit of the UKCJS. A public sector R&D group free from commercial constraints could provide innovation, training, guidance and aid as appropriate to commoditised FSPs and police forces as required. For example, this could support increasing standardisation and quality monitoring whilst providing capacity for critical and national security investigations unencumbered by the restraints of contractual commitments to provide standard products for routine CJS work.

9. The lack of specific RCUK funding for forensic science can be addressed through periodic calls (cf. EPSRC Think Crime). Without centrally funded support FSPs and police forces will not have sufficient capital to maintain an R&D advantage for the UK. FSS has maintained a high success rate in applications by careful application of practitioner knowledge integrated with research opportunities. However, follow–on funding is required to further develop those projects and ideas which show promise of contributing to the CJS.

Q5. What are the important international networks and how useful are they? Do you have any specific international collaborations you would wish to draw to our attention?

10. The most active group in Europe is the European Network of Forensic Science Institutes (ENFSI). ENFSI's DNA working group is very productive and strives to ensure best practice is followed throughout Europe. A number of trials and recommendations are published. Working with ENFSI has allowed FSS to remain involved in critical research areas to which it would have otherwise been unable to contribute due to commercial pressures e.g. use of mRNA for cell type identification.

11. FSS R&D is currently the lead partner in a European FP7 project with 3 of the leading forensic laboratories in Europe, a UK SME and a US University to develop a casework system for DNA analysis in under 2 hours [10].

Q6. Are there any other issues relevant to our terms of reference that you would wish to comment on?

12.

Many leading scientists have recommended a model in which efficiencies are gained by consolidating necessary but non-profitable functions currently spread across several different public bodies R&D (FSS), database maintenance (NPIA), quality (Forensic Regulator), training and international representation (FSPs but predominantly FSS), Cold Case Review and archives (FSS)[1,11]. This would provide an ideal environment for a strategic R&D function which could deliver coordinated long term plans faster and to a robust, accredited standard ready for immediate implementation.

References

[1] "Closure of Forensic Science service puts Justice at Risk" Professor Niels Morling – President of International Society for Forensic Genetics (ISFG) *et al*., Letter to *The Times*, 28th December 2010

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[8] S&T Committee: Written evidence Forensic Science Service: 24 February 2011 from London Toxicology Team (submission 42)
[9] S&T Committee: Written evidence Forensic Science Service: 24 February 2011 (submissions 23 & 66 amongst others)
[10] http://www.forensic.gov.uk/html/company/partnership/
[11] S&T Committee: Written evidence Forensic Science Service: 24 February 2011 submissions from Alec Jeffreys; Kevin Sullivan and Peter Gill.

RAND

Dear Professor Silverman,

Thank you for your 16 February invitation to submit information regarding research relevant to Forensic Science. RAND Europe, which is an independent not-for-profit research organisation, has conducted research of interest to you. RAND Europe has offices in Cambridge, UK, and Brussels, and works with colleagues at our parent organisation, the RAND Corporation, based in the US. We share a mission to improve policy and decisionmaking through objective research and analysis.

I am pleased to submit the following responses to your questions.

Yours sincerely

Sir Mark Walport
Director

1. ***What work relevant to forensic science is being done in your group/university and what are the opportunities for the future?***

We wish to draw to the attention of the review a number of relevant publications:

Paper that uses UK Forensic Data on drug purity: Caulkins, Jonathan P., Sudha S. Rajderkar, and Shruti Vasudev. 2010. *Creating Price Series without Price Data: Harnessing the Power of Forensic Data. Appendix A in B*. Kilmer and S. Hoorens (Eds.) Understanding Illicit Drug Markets, Supply Reduction Efforts, and Drug-Related Crime in the European Union (pp.165-196). Cambridge U.K.: RAND RAND TR-755-EC

Abstract. Data on (purity-adjusted) prices of illegal drugs are valuable for many purposes, particularly when high-frequency series are available (e.g., weekly or monthly, not just quarterly or annually). Over the last fifteen years, methods have been developed for creating price series using data from undercover purchases, such as those included in the U.S. Drug Enforcement Administration's STRIDE database. However, most countries around the world do not conduct enough undercover purchases for these methods to be practical. Some countries that do not make many undercover buys nevertheless seize illegal drugs frequently and quantitatively analyse the purity of the samples. This paper describes and validates a method to create high-frequency, purity-adjusted price series using just such forensic data on purity, plus occasional (e.g., annual) observations of the nominal price per raw gram.

Paper on use and processing of DNA evidence: Jeremiah Goulka, Carl Matthies, Emma Disley, Paul Steinberg (2010) Toward a Comparison of DNA Profiling and Databases in the United States and England, Santa Monica, CA, RAND Corporation TR-918-ISEC

Abstract: This sought to compare DNA Profiling and Databases in the United States and England. There is a perception amongst many in the US law enforcement community that the English criminal justice system has capitalised more fully on the crime-fighting potential of forensic DNA evidence than the U.S. criminal justice system. The perception is rooted in claims that England conducts forensic DNA analysis more quickly and inexpensively and has a higher "hit" rate. This report investigates this perception. This work was funded by the RAND Centre for Quality Policing Consortium

(http://www.rand.org/ise/centers/quality_policing.html). The headline finding for this work is that there is a lack of reliable data for robust analysis or on which to base international comparisons. However, the report does highlight the potential for future work in this area which employs a comparative or international benchmarking approach.

Paper using forensic data from the US: Caulkins, Jonathan P., Rosalie Liccardo Pacula, Jeremy Arkes, Peter Reuter, Susan Paddock, Martin Iguchi,

and Jack Riley. 2004. *The Price and Purity of Illicit Drugs: 1981 Through the Second Quarter of 2003*. Report prepared by RAND and published by the Office of National Drug Control Policy as Publication # NCJ 207768, November.

Abstract: Since drugs are provided through illegal markets, it is natural to want to track data series pertaining to prices as well as more traditional indicators of demand, use, and quantities consumed. This report continues a series produced by the Office of National Drug Control Policy (ONDCP) and attempts to improve the understanding of trends in prices and purity for five major illicit drugs: powder cocaine, crack cocaine, heroin, d-methamphetamine, and marijuana in the United States from 1981 through the second quarter of 2003, using data from the Drug Enforcement Administration's (DEA) System to Retrieve Information from Drug Evidence (STRIDE) database. The report is divided into two major sections: (1) results of the price and expected purity of the five specific drugs and (2) the purity of drugs once seized. The results of illicit drug prices indicate that they are still extraordinarily high per unit weight. This is even though prices have declined over the past 20 years. In addition, drug prices have extreme variability over quantity levels, between locations, over time, and from transaction to transaction. Prices also vary substantially over time. The overall trend for powder cocaine, crack, and heroin shows a steep decline during the 1980's, a spike in prices in 1989 through 1990, then relatively stable with a modest decline during the 1990's and early 2000's. Trends and variation in purity are drug-specific but are also quite common. Cocaine purities are now typically fairly high at all quantity levels, and heroin is much more pure than it was in the early 1980's. Additional research is recommended in focusing, not only on further refining and updating of descriptive trends, but also on correlating the trends with other data indicators. Tables and figures

2. What previous and current research partnerships do you have with forensic science providers, police forces, the National Policing Improvement Agency, etc.?

RAND has well established research partnerships with SOCA and related bodies with whom we are working on developing new metrics. We have been commissioned by the Home Office, Ministry of Justice and NPIA, and have interviewed or worked with individuals in the UK NPIA, UK police forces, US police forces, US labs and UK labs for the projects and reports listed above. The RAND Centre for Quality policing also has long-established links with senior US law enforcement officials.

3. Can you give good examples in the forensic science field of translation of research into practice, and also any examples where this has been difficult or problematic?

RAND has helped law enforcement practitioners consider the implications of forensic purity assessments for measurement and understanding of illicit drugs markets.

4. What do you see as the opportunities for, and the barriers to, the funding of research relevant to forensic science?

We believe there could be significant potential for international, comparative research or benchmarking.

5. What are the important international networks and how useful are they? Do you have any specific international collaborations you would wish to draw to our attention?

RAND is an international research organisation with international and pan-European collaborations across a range of projects. We work with European Monitoring Centre on Drugs and Drug Addiction on a range of our projects.

6. Are there any other issues relevant to our terms of reference that you would wish to comment on?

RCUK

MEMORANDUM FROM RCUK IN RESPONSE TO THE HOME OFFICE REVIEW OF RESEARCH AND DEVELOPMENT RELEVANT TO FORENSIC SCIENCE

1. Research Councils UK (RCUK) is a strategic partnership set up to champion research supported by the seven UK Research Councils. RCUK was established in 2002 to enable the Councils to work together more effectively to enhance the overall impact and effectiveness of their research, training and innovation activities, contributing to the delivery of the Government's objectives for science and innovation. Further details are available at www.rcuk.ac.uk

2. This evidence is submitted by RCUK on behalf of the Research Councils listed below and represents their independent views. It does not include, or necessarily reflect the views of the Knowledge and Innovation Group in the Department for Business, Innovation and Skills (BIS). The submission is made on behalf of the following Councils:

   Arts and Humanities Research Council (AHRC)
   Biotechnology and Biological Sciences Research Council (BBSRC)
   Engineering and Physical Sciences Research Council (EPSRC)
   Economic and Social Research Council (ESRC)
   Medical Research Council (MRC)

What research do you fund relevant to forensic science?

3. The AHRC funds a small amount of research in forensic archaeology and forensic linguistics. These are applied braches of archaeology and linguistics where archaeological or linguistic principles and methodologies are applied in a legal context. There are established centres for these disciplines within UK universities.

4. BBSRC and the Home Office held a joint Genomics workshop in November 2010 which identified: the current and potential capabilities of genomics and their implications for the Criminal Justice System (CJS); ethical issues these advances may raise; and bioinformatics. The workshop increased the engagement between HO practitioners and leading researchers in the genomics field.

5. EPSRC's Technologies for Crime Prevention and Detection Programme ran from 2002 to 2008 and funded several projects and networks related to forensics during that time. These included the Geoforensics and information management for crime investigations network[25], which aimed

[25] http://gow.epsrc.ac.uk/ViewGrant.aspx?GrantRef=EP/D041473/1

to find cutting-edge technologies that would help in future forensic investigations. In 2006 EPSRC held an event called *The future of forensics*,[26] focusing on the contribution that EPSRC-funded science and engineering made to the development of forensic science.

6. The ESRC Deafness Cognition and Language Research Centre (DCAL)[27], have an associated project that investigates 'Forensic Applications of Lipreading'. Run in association with Deafworks, this Home Office funded project collates scientific evidence on the reliability of lipreading in understanding videoed conversations that lack a sound track. Further, the professional experience of deaf lipreaders who do this work is examined as part of the project.

7. The ESRC Genomics Network (EGN)[28] is a major investment by the ESRC, examining the development and use of the science and technologies of genomics. It incorporates three research centres – Cesagen, Egenis and Innogen, and a Genomics Policy and Research Forum. The activities of the EGN span the whole field of genomics, covering diverse areas, including research addressing the ethical, legal and social issues raised by the collection, storage and use of DNA and genetic information in forensic databases.

8. MRC does not directly fund applied forensic science research. It does however support basic biological research which may underpin the development of forensic science, such as Sir Alec Jeffreys' work on DNA fingerprinting[29] and research which informs the development of diagnostic technologies which may have dual application.

9. Further examples of Research Council funding of forensic science including support for facilities and relevant expertise is provided at Annex A.

Do you have any mechanisms specifically to support forensic science research?

10. Research Councils do not currently support forensic science research as a strategic priority.

Do you have any mechanism for identifying any potential forensic spin off from the broad range of funded research projects? Should there be such mechanisms?

[26] http://www.epsrc.ac.uk/newsevents/news/2006/Pages/futureofforensics.aspx
[27] http://www.dcal.ucl.ac.uk/Research/associated_projects.html

[28] http://www.genomicsnetwork.ac.uk/
[29] http://www.mrc.ac.uk/Achievementsimpact/Storiesofimpact/DNAresearch/index.htm

11. As part of the Research Council application and assessment process applicants are asked to think carefully and answer questions on who could potentially benefit from their work in the longer term and consider what could be done to increase the chances of their research reaching those beneficiaries. These sections (Impact Summary and Pathways to Impact) provide an opportunity for applications to identify potential for any spin-offs which may result from their research.

12. Research Councils offer a variety of follow-on funding schemes to grant-holders which enables researchers to develop the outputs from existing research in order to achieve significant economic, social and/or cultural impact. Follow-on funding can be suitable for early stage 'proof-of-concept' investigations or the translation of research into policy and practice.

13. Several recent EPSRC grants include organisations with an interest in forensics as project partners, including
    13.1. The Forensic Science Service - Commercialisation of Lab-on-a-Chip technology for DNA profiling (http://gow.epsrc.ac.uk/ViewGrant.aspx?GrantRef=EP/H007385/1)
    13.2. Forensic Pathways - Analysing Security and Privacy Properties (http://gow.epsrc.ac.uk/ViewGrant.aspx?GrantRef=EP/H005501/1)
    13.3. HOSDB, DSTL, NHS - Nanoconjugates for the detection of forensic residues (http://gow.epsrc.ac.uk/ViewGrant.aspx?GrantRef=EP/G005850/1)

Are you aware of any real or perceived barriers to the funding of forensic science research and are there ways that could be explored to overcome these?

14. RCUK is not aware of any barriers to the funding of forensic science research. Any forensic science grant proposal submitted to a Research Council from an eligible institution which is both within that Research Council's remit and judged by independent peer-review to be excellent would have the same opportunity to be awarded funding as a proposal from any other discipline.

Are there any other issues relevant to our terms of reference that you would wish to comment on?

15. The review might like to be aware of the RCUK Global Uncertainties Programme. This cross-Council activity is intended to help research contribute to the security of individuals, organisations and countries. It has six core themes; forensic science can make a useful contribution to several of these, in particular to those on terrorism and trans-national

organised crime. Several of the grants accredited to the programme are in the area of forensic science. More details of the programme are available at http://www.globaluncertainties.org.uk/.

Research Councils UK, March 2011

ANNEX A

Further examples of Research Council funding of forensic science

Forensic Linguistics: Applied Sociolinguistics and the Law - http://www.ahrc.ac.uk/FundedResearch/Pages/ResearchDetail.aspx?id=138857

Nanoconjugates for the detection of forensic residues - http://gow.epsrc.ac.uk/ViewGrant.aspx?GrantRef=EP/G005850/1 (Follow on fund - finished 2010)

Development of complementary technologies for forensic and security screening - http://gow.epsrc.ac.uk/ViewGrant.aspx?GrantRef=GR/S63045/01 (finished 2007)

Network to Develop Applications of Stable Istotope Mass Spectrometry in Forensic Science & Crime Detection - http://gow.epsrc.ac.uk/ViewGrant.aspx?GrantRef=GR/R72426/01 (finished 2005)

Development of Novel High Sensitivity and Specific Methods to Provide Reliable Forensic Evidence of Drug Administration in Vulnerable Groups - http://gow.epsrc.ac.uk/ViewGrant.aspx?GrantRef=EP/C533437/1 (finished 2008)

Science in a legal context: DNA profiling forensic practice and the courts http://stage.esrc.ac.uk/my-esrc/grants/R000235853/read

Egenis (The ESRC Centre for Genomics in Society) has an active research project on 'The use of forensic DNA technologies in police practice' http://www.genomicsnetwork.ac.uk/egenis/research/governanceregulationandpublicinterest/projecttitle,23782,en.html
The ESRC Genomics Forum was a partner in the Human Genetics Commission's Citizens' Inquiry (2008) into the forensic use of DNA and genetic information http://www.hgc.gov.uk/Client/news_item.asp?NewsId=101
The ESRC Genomics Forum hosted an expert workshop in 2008 entitled Genetic Suspects: Emerging Forensic Uses of Genomic Technologies http://www.genomicsnetwork.ac.uk/media/genetic_suspects.pdf
Egenis (The ESRC Centre for Genomics in Society) is hosting the following seminars: 'Forensic DNA Databasing Policy & Practice: Imagining and Assessing Utility' with Professor Robin Williams on 09 May 2011, and 'Emerging Forensic DNA Technologies: Risks, Realities and Representations' with Dr Chris Lawless on 13 June 2011.
http://www.genomicsnetwork.ac.uk/egenis/events/seminars/title,23763,en.html
http://www.genomicsnetwork.ac.uk/esrcgenomicsnetwork/events/seminars/title,23764,en.html

Various laboratories at British Geological Society (BGS) have contributed to forensic geosciences, e.g.
http://www.bgs.ac.uk/laboratories/biostratigraphy/home.html

Data from BGS's digital "Parent Material Model (PMM)" is being assessed for its use in forensic science.

http://www.bgs.ac.uk/science/landUseAndDevelopment/sustainable_soils/parentmaterialmap.html
BGS palaeontologists have provided forensic science consultancy services.
http://www.bgs.ac.uk/science/biostrat/Consult.html
Fingerprints hide lifestyle clues
http://news.bbc.co.uk/1/hi/technology/4857114.stm

Shoeprint analysis to fight crime
http://news.bbc.co.uk/1/hi/technology/4857756.stm

THE ROYAL STATISTICAL SOCIETY

1 The continuation of the research and development work of the Forensic Science Service is essential for continuing improvements in the administration of criminal justice, with the consequential savings that will accrue from any improvements. The return on investment will be considerable. It is crucial for the Home Office to have high quality forensic scientific research input and this is not available from the private sector, for whom the priorities are very different. Funding will be required from the public purse.

2 The research work done by the Forensic Science Service is of high scientific quality. The most notable example is the introduction of forensic DNA as a service. A second is a Read Paper to the RSS in September on models for fingerprint analysis written by FSS researchers (though one has now moved to the USA). If the proposed closure of the FSS goes ahead it will severely damage the research and development of scientific methods for the successful investigation of crime and the logical evaluation and interpretation of evidence. The FSS has consistently provided excellent researchers in their employ with the time and space to develop their ideas with the subsequent long-term benefits to the administration of justice. Peter Gill and others at the FSS took the research of Sir Alec Jeffreys and brought it into practice. The ability for serendipitous ideas to emerge will be severely curtailed by the closure of the FSS.

3. Statistics is important as a subject because it is the science that enables an objective assessment of evidence in the presence of uncertainty. At present, the FSS employs several qualified statisticians, Dr Ian Evett, Dr Roberto Puch-Solis, Dr Lauren Rodgers and Dr Anjali Mazumder, to support practice and research. The statisticians are members of the Statistics and Interpretation group, which also have two engineers, Ismael Mateos-Garcia and James Skerrett, and a biologist, Amanda Kirkham. This group is a crucial resource in research and development and will be broken up with the closure of the FSS. No commercial provider will be able to maintain such a group. As far as we know, LGC forensics employs a statistician but we are not aware whether other forensic providers in the UK do employ statisticians. The Netherlands Forensic Institute in The Hague employ several statisticians.

4. The FSS group has led the way in methods for evidence interpretation and evaluation leading to the current Case Assessment and Interpretation procedures in place today. At present the Statistics and Interpretation group (see paragraph 3 above), following the experience of Ian Evett and Peter Gill, is working in bringing academic research into practice in two main forensic evidence types: DNA and fingerprints. Without the close connection to casework, it is unlikely for the group to have the insight to complement academic research and to develop systems that are fit for casework. Researchers working in universities require the group at the FSS, or some equivalent (see paragraph 5 below) to inform the universities' research. A research group in the FSS, or some equivalent, is important for the taxpayer because the benefits of investment on research is realised in practice. It is difficult to see such work being enabled in a commercial environment.

5. If the FSS were to close, the creation of an independent national forensic science institute with core funding from the public purse is the only way in which research and development can be continued. Recommendation 1 of the 2009 National Academy of Sciences report from the USA (http://www.nap.edu/catalog.php?record_id=12589) should be studied carefully and a version tailored to the UK legal system developed. The following comment on p. S-15 of that report, immediately following Recommendation 1, is of relevance:

"The benefits that will flow from a strong, independent, strategic, coherent, and well-funded federal program to support and oversee the forensic science disciplines in this country are clear: The Nation will (1) bolster its ability to more accurately identify true perpetrators and exclude those who are falsely accused; (2) improve its ability to effectively respond to, attribute, and prosecute threats to homeland security; and (3) reduce the likelihood of convictions resting on inaccurate data. Moreover, establishing the scientific foundation of the forensic science disciplines, providing better education and training, and requiring certification and accreditation will position the forensic science community to take advantage of current and future scientific advances."

Whilst this response has been put together on behalf of the RSS by its Statistics and Law working group, it is not to be taken that all members of the group agree with all the points made. In particular, the group contains representatives of various legal institutions and the views expressed in this response should not be taken to also be the official view of these institutions.

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WELLCOME TRUST

Dear Bernard

Forensic Science Research and Development

The Trust welcomes the opportunity to contribute to the Home Office review of forensic science research.

By way of background, the Wellcome Trust is a global charitable foundation dedicated to achieving extraordinary improvements in human and animal health. We support the brightest minds in biomedical research and the medical humanities. Our breadth of support includes public engagement, education and the application of research to improve health.

The Trust's interests in forensic science are focused mainly at fundamental research that underpins forensic science and projects related to medical humanities. We have therefore restricted our response to answering question 1 only, 'What research do you fund relevant to forensic science?'.

We are particularly committed to advancing knowledge of human genetics, and from 1990-2009 the Trust committed around 10 percent of its funding (£740 million) to human genetics research. We have been extensively involved in genetics research and the Wellcome Trust Sanger Institute, Cambridge, has been an important player in the human genome project continues to be a world leader in breakthroughs in genetics research today[i]. Research in the field of human genomics has the potential to impact on the development of forensic techniques and technology in the future.

We would like to take this opportunity to highlight that research in bioethics and the medical humanities, and ongoing public engagement activities, have a crucial role to play in informing and shaping the application of forensic science research and associated technologies in society.

The Trust is aware of both the complex ethical issues that surround the use of genomic information and DNA databases and the need for public engagement on this controversial topic. Therefore the Trust has funded grants in this field via our Biomedical Ethics programme and our various Public Engagement funding schemes, which have included co-funding the Citizen's Inquiry into 'The Forensic Use of DNA and the National Digital Archive of Datasets (NDAD)[ii].

The Trust has also sought to promote a deeper understanding of forensic science by funding historical research that examines the rise of this field in its cultural and societal context. Relevant activities include:

- "Inside DNA: a genomic revolution" – a unique 5-year touring exhibition that encourages visitors to explore the issues underlying genomics research. Feedback from this exhibition is being shared with the Human Genetics Commission (HGC);

- "The National DNA Database on Trial: Avoiding the Usual Suspects" – participants in this mock trial held in November 2008, consisted of people aged 16-19 whose details are already on the NDNAD. Findings were presented to both the HGC and Welsh Assembly;
- "Forensic DNA Databasing: A European perspective" – a Biomedical Ethics grant to Professor Robin Williams and Dr Paul Johnson to explore the growth of national DNA databases across European states; the implications of increased trans-national forensic DNA data sharing across the EU and the major legal, social and ethical issues arising from the emerging global trends in the forensic use of DNA;
- "Governing Genetic Databases" – a Biomedical Ethics grant awarded to Professor Michael Parker and Dr Jane Kaye from the Ethox Centre, University of Oxford, and Dr Andrew Smart of Bath Spa University. This project reviewed the current legal framework, analysed existing database governance practices, and made recommendations for the effective governance of genetic databases in the future;
- "The Human Body, Its Scope, Limits and Future" – a major five-year Strategic Award in Biomedical Ethics awarded to Professor John Harris and colleagues at the University of Manchester and Professor Sarah Cunningham-Burley at the University of Edinburgh in 2008. Two key strands of their research programme cover the uses of human organs and tissues, with a particular focus on the regulation of biobanks, and ethical and legal issues around the uses of genetic information;
- The Wellcome Library has purchased the "Personal Papers of Sir Bernard Spilsbury (1877-1947)", the only significant collection of personal papers of this (controversial) pioneer of forensic medicine; and
- Historical research into various dimensions of the rise of forensic medicine, including the history of forensic toxicology in Britain (Dr Katherine Watson, Oxford Brooks) and a history of forensic homicide investigation in 20th-century England (Dr Ian Burney, Manchester University).

The Trust also makes significant funding contributions to cognitive research and neuro-imaging and funds research exploring the ethical and legal aspects of the latest developments in neuro-imaging and other areas of neuroscience. We acknowledge that there has been interest in the potential of neuro-imaging to be used in forensic science, for example in lie-detection. However, we would urge that the early stage of research in this field means that it will not be ready to apply in the forensic context in the near future. Furthermore, the ethical implications of the wider use of neuro-imaging in society will need to be explored in public debates and through further research in bioethics, in a similar way to projects supported by the Trust surrounding the use of DNA.

Advances in technology offer huge opportunities for forensic science now and in the future. To optimise the benefit of such advances, it is essential that the limitations and implications of these technologies are openly acknowledged and discussed with the public.

Yours sincerely
Sir Mark Walport
Director

[1]http://www.wellcome.ac.uk/stellent/groups/corporatesite/@policy_communications/documents/web_document/wtx063661.pdf
[1] http://www.hgc.gov.uk/UploadDocs/DocPub/Document/Citizens%20Inquiry%20-%20Citizens%20Report.pdf

WEST MIDLANDS TOXICOLOGY LABORATORY

1. The scale, scope and impact of the research and development carried out by forensic science providers and related organisations (in the public and private sector).

Scale of R & D: *e.g. your research budget; capital investment in R & D; size of research workforce; details of dedicated facilities.*

The West Midlands Toxicology Laboratory has no dedicated budget, staffing, equipment or facilities for R&D. This developmental aspect of service provision is performed using existing routine service resources as they allow, in response to new demands placed on the service by its users. These may originate from clinical sources rather than forensic enquiries in the first instance (e.g. development of new techniques to detect new chemical entities) but the outcome can then be applied to forensic case work as required. In the vast majority of cases, new chemical entities are seen clinically prior to becoming a forensic issue.

Scope: *e.g. topics of recent and current interest in your own organisation's research; suggestion of any areas where you feel more research would be useful. Impact: e.g. examples where your research has had impact, or will have obvious impact, on forensic science provision and practice.*

The most pressing area being currently addressed is the application of screening techniques to determine the presence or absence of new designer drugs e.g. mephedrone and spice. The major problem in this respect is that new chemical entities can be produced, marketed and used / abused faster than pure reference standards can be made available. In addition, once available these reference materials are typically very high cost items which most laboratories cannot afford to purchase in any great numbers. This results in a prioritisation of acquisition and subsequent method development which then either lags behind drug use, or creates a lack of ability to monitor for the presence of such entities without partnerships with other providers of analytical services (clinical or forensic).

Partnerships: *to include details of research and development partnerships, both in the UK and abroad. (Also relevant to items 3 and 4 below.)*

The West Midlands Toxicology Laboratory does collaborate with other similar laboratories with the aim of providing as broad a range of services as possible. However, this typically relates to mutual access to specialist analytical services ratherthan collaboration on R&D activities.
Funding: to include details of externally funded projects, source of funds, projectscope, time scales and progress. (Also relevant to item 3 below.)

The West Midlands Toxicology Laboratory is currently not enrolled on any externally funded projects.

2. The extent, and the ways in which, forensic science practice assesses the relevance of, and accesses, the latest advances in technologies and techniques.

How do you bring current scientific developments into practice? Please explain any mechanisms and/or give examples. Are there any barriers to this process?

Information on the latest developments (applications or techniques) is gleaned from peer reviewed articles or discussion with scientific colleagues at meetings. If possible, the West Midlands Toxicology Laboratory responds to these by reviewing existing equipment capabilities and then attempting to develop and validate techniques to fulfil requirements. If the technology is not appropriate, then the work will have to be performed elsewhere and it may then be possible to gain access to these developments through existing professional links or by subcontracting work. The largest barriers to this process are financial constraints regarding acquisition of raw materials and step costs for staffing, and technological constraints for equipment capabilities. Unless there is sufficient market sustainability for new developments, they will either fail to be achieved or maintained.

3. The scale and scope of forensic science research undertaken in academia and its links with forensic science practice.

What links, if any, do you have with academia, and what value do you place on these? Please also comment on the value of academic work to your business, whether or not it is part of a specific or explicit link.

The West Midlands Toxicology Laboratory has enjoyed links with several Universities over the years. This is vital for the future development of high level science and scientists. Such collaborations may involve student exchange for R&D activities, or access to technology not typically available. The resultant developments are then put into practice wherever practicable However, funding and equipment access is always tight.

4. The current and potential contribution of international research networks to UK forensic science research and practice.

Please give any specific examples or comments.

The UK used to lead the world in terms of forensic science, its practice and its development. Unfortunately this has now changed. Many countries both within and outside of Europe have now surpassed the UK in terms for forensic science provision (scope and capability). Developments can be accessed either through collaboration or from the application of new knowledge following attendance at meetings. Discussion with professional colleagues at such meetings will always outstrip the information that can be gleaned from subsequent publications of abstracts. However, funding for attendance at international meetings can be difficult to access.

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[i] http://www.wellcome.ac.uk/stellent/groups/corporatesite/@policy_communications/documents/web_document/wtx063661.pdf

[ii] http://www.hgc.gov.uk/UploadDocs/DocPub/Document/Citizens%20Inquiry%20-%20Citizens%20Report.pdf