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ENCOURAGING INNOVATION

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The UK has a strong track record of innovation in forensic science, and its forensic science providers have a close working relationship with the police. Engaging all of the partners involved in taking innovations through to market adoption – including academia, industry, end users and government – gives the UK an opportunity to become a global leader in the forensic science market. The government now has an important role to play in helping innovators to bridge the 'valley of death' as they seek to turn proof-of-principle techniques into commercial products.

Forensic science is a multidisciplinary field that relies on technologies and methodologies from a wide range of sectors. Although it primarily addresses questions relating to crime, it also covers a wider spectrum of activities such as consumer and environmental protection, health and safety, the authenticity and provenance of goods, and civil proceedings such as breach of contract and negligence. Intelligence, gathered overtly or covertly, can also predict when crimes are about to take place, enabling pre-emptive interventions or better evidence-gathering. As a result, forensic science makes a significant contribution to our justice and security systems, ensuring our economic stability.

The UK has a strong track record of innovation in this area, including the development of fingerprinting, and more recently DNA profiling. Forensic science provides innovators with potential opportunities in a diverse range of disciplines, as well as a truly global market for its scientific and technological developments. Moreover, England and Wales remain the only countries to have privatised all of their forensic science services. This has created a closeness between the private sector and police service users that is relatively unique compared with the rest of the world.

These factors mean that the UK could become the best place in the world to commercialise forensics innovations in the future – as long as the right market dynamics can be created. In particular, all of the partners involved in taking proof-of-principle innovations through to market adoption – including academia, industry, end-users and government – need to work together to bridge the 'valley of death' that so often prevents high-technology products from realising their commercial potential.

MAPPING THE INNOVATION LANDSCAPE: FROM CONCEPT TO IMPLEMENTATION

According to the Crown Prosecution Service's (CPS) Code for Crown Prosecutors, evidence may only be used in court if the prosecutor is satisfied that it is reliable, credible and admissible. The high cost and judicial impact of failing to meet these standards means that any forensic technique must be validated to a high level, and backed by a strong evidence base, before it is used in criminal investigations. That makes the innovation landscape for forensic science more complex, with a diverse range of stakeholders at all points on the route from concept development through to implementation (see Box 1). Chapter 17 contains a more detailed look at these stakeholder groups, and their interactions.

This complexity and diversity means that no two stakeholders have the same strategic priorities or pressures, and all have different perspectives and interpretations about what forensic science is, and what it can and cannot do. Another consequence, not unusual in multidisciplinary innovation, is the lack of a common taxonomy.

All stakeholders need to engage and communicate directly with all other members of the value chain. In particular, the pull from the Criminal Justice System (CJS) must not be lost in the noise. Engagement should take place in the context of a national strategy, with universal buy-in. Scientific excellence, commercial success and just outcomes will depend on consistent implementation of government strategy, including sufficient funding and open communication. Potential mechanisms for such engagement are discussed further in the chapter.

RISKS, BARRIERS AND CHALLENGES TO INNOVATION

In 2014, The Government Chief Scientific Adviser has previously said[1]:

"Advances in science and technology can yield significant societal benefits and drive economic growth. The challenge for society is to channel existing evidence about innovative technologies and their risks to improve decision making in the area of regulation and policy making."

This accurately summarises the cost-benefit analysis that must be completed before new technologies are applied within the forensic science sector. This poses several challenges for any innovator or technology developer, who must identify:

- The unmet need within forensic science that can provide a suitable return on investment and that is compatible with their existing capabilities
- The customers that require and are willing to pay for the service or product
- The key opinion leaders within the sector that will champion the innovation through to its eventual implementation
- The value proposition of providing such a solution, i.e. what level of investment is required, and how long before a return is achieved
- Who are the main competitors
- The regulatory hurdles prior to implementation
- The risks associated with translating the technology from the laboratory to the real world (e.g. degradation of analytical performance, in terms of reproducibility and false positives or false negatives)
- The sources of financial input at each stage of innovation

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Courts require that forensic evidence is based on processes and scientific principles that have very little uncertainty. This inevitably means that there will be some inertia against new technologies, due to the serious impacts caused by the failure of a forensic method. These risks can be reduced by ensuring that any new innovations are compliant with existing standards and best practice, in particular the Forensic Science Regulator's Codes of Practice and Conduct, CPS guidance, and the relevant legislation. These codes include guidance on the processes to be used for validation, accreditation and implementation of an innovation, from the initial research and development phase, followed

Box 1: Forensic science stakeholders in the UK

- **Academia** (e.g. universities)
- **Funding bodies** (e.g. Research Councils UK, Innovate UK, Police Innovation Fund)
- **Forensic service providers, including larger companies** (e.g. LGC Ltd, Key Forensic Services Ltd, Cellmark Forensic Services) and small and medium-sized enterprises (SMEs)
- **Law enforcement agencies** (e.g. Police service, National Crime Agency, Operational Counter Terrorism users)
- **Government departments** (e.g. Home Office, Ministry of Defence)
- **Regulators** (e.g. Forensic Science Regulator)
- **Guidance and best-practice providers** (e.g. Crown Prosecution Service, College of Policing, National Police Chief Council, Centre for Applied Science and Technology, Defence Science and Technology Laboratory, Forensic Science Special Interest Group, European Network Forensic Science Institute)
- **Accreditation Providers** (e.g. UKAS: see Chapter 3 case study p34)
- **Networking** (Chartered Society of Forensic Science, Association of Forensic Science Providers, Forensic Science Special Interest Group, European Network Forensic Science Institute)
- **End users** (Crown Prosecution Service, Courts, Counter Terrorism and Intelligence)
- **Journalists**
- **General public, including victims of crime**

by pilot studies, use on live samples, first CPS case management and its first test in court. The codes also detail how the whole process should be monitored and reviewed. Direct communication between scientists and end-users in the CJS is key to ensuring that innovation is implemented in a timely manner.

Other potential end-users of forensic science are the military, counter-terrorism and intelligence agencies. Their operational needs are likely to be different from those of the courts, and therefore a dialogue with organisations such as the Defence Science and Technology Laboratory (Dstl) and the Centre for Defence Enterprise (CDE) are essential to establish end-user needs and ensure that the innovation will be fit for purpose. Forensic tools can also be used to determine authenticity in areas including clothes, foods or perfumes, which require liaison with industry and regulatory bodies.

But the primary customers (and budget holders) for most innovations in forensic science are law enforcement agencies or forensic service providers (FSPs). Increasingly, police forces are bringing more forensic services within their organisations, blurring the lines between themselves and FSPs. The main risk for the law enforcement agency is that their investment results in a procedure that is not suitable for use in the Criminal Justice System. Once again, early engagement between scientists and the CJS is key.

For an FSP, there is an additional risk that their investment in an innovation does not provide a return. That financial return is only possible if the innovation is monetised and adopted by a sizeable market, with a proportion of the revenue returned to the service provider and ultimately the innovator. This monetisation could be through the provision of a service directly to the customer, or more likely through the licensing of the intellectual property to one of the leading service providers in the sector. For any innovation to be widely implemented, it must either speed up a current methodology or satisfy an unmet need; have limited competition; and be successfully transferred from the controlled environment of the laboratory into the real world, where it can be used by non-experts. The overall cost of implementing the technology into the forensic workflow will also need to be minimised to avoid driving up costs to the customer.

It is clear from both case studies in this chapter that securing funding to move from the initial research and development phase at an academic institution, through to the development of a commercial product, remains difficult (see case studies on p179 and p181).

Partnerships between academic institutions and end-users can help to guide innovations through this development process. Potential innovators – who may be new to the sector – should be made aware of the wider global markets, and their high esteem for UK forensic science; as well as existing networking opportunities. For example, the Forensic Science Special Interest Group (FoSci SIG) is a community that includes everyone involved in forensic science, and enables closer networking and better communication between all stakeholders for improved research and development. FoSci SIG is run by the Knowledge Transfer Network (KTN) and was set up in July 2012 following a recommendation in June 2011 by the Home Office Chief Scientific Adviser in his review of 'Research and Development in Forensic Science'. FoSci SIG has an online searchable database of challenges in forensic science, which helps to match key questions with innovators' potential solutions[2].

FOR ANY INNOVATION TO BE WIDELY IMPLEMENTED, IT MUST EITHER SPEED UP A CURRENT METHODOLOGY OR SATISFY AN UNMET NEED; HAVE LIMITED COMPETITION; AND BE SUCCESSFULLY TRANSFERRED FROM THE CONTROLLED ENVIRONMENT OF THE LABORATORY INTO THE REAL WORLD.

TURNING SCIENCE INTO FORENSIC SCIENCE

Fundamental 'blue skies' research usually takes place in universities with the support of research council funding. Some of these activities will result in capabilities that may be of benefit to forensic science. The challenge for the community is in identifying those projects,

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especially when the innovation is initially applied in a different discipline.

If the project is more applied, then the academic researchers need to have a clear understanding of the realities of the end-user needs and environment, which can only be gained through interaction with an end-user, and ideally with the wider stakeholder community. Increasingly, the importance of applied research is being acknowledged within universities and the research councils. All research council proposals must demonstrate 'Pathways to Impact', including how researchers will communicate, engage and collaborate with stakeholders and potential beneficiaries of the research.

There is also a growing expectation within universities that research should be translated, with any revenue generated being returned to the university. This strategy is further encouraged through the Quality Related-Business Research Element (QR-BRE) funding from the Higher Education Funding Councils of both England and Wales, and by the fact that an assessment of impact now makes up 20% of the Research Excellence Framework, and therefore directly influences future mainstream Quality Related (QR) research funding in all UK universities.

However, it should also be acknowledged that the current requirement for an academic to achieve traditional 'outputs' for their research (80% weighting) is also a barrier to investing time in activities such as validation, which may not be publishable in peer-reviewed journals but is crucial for the end-stage of adoption of a technology.

To help these applied projects, it is important that the sector establishes and supports events that actively engage all stakeholders and generate opportunities for networking; offers funding for proof-of-principle studies and/or staff exchanges; and provides commercial training on how to develop an initial idea into a business plan, so that innovators can attract follow-on funding from agencies such as Innovate UK. The Network+ schemes being organised by the Science and Technology Facilities Council (STFC) and the Engineering and Physical Sciences Research Council (EPSRC) provide such funding, but the field also needs a forensic science champion for these schemes, with a proven track record of engaging with the other key stakeholders in the sector.

Any intellectual property generated by this research could be exploited in two ways. It could be licensed to an FSP or commercial organisation, which would then develop the product and take it to market, eventually providing a revenue stream to the university. Alternatively, the academics involved could form a spin-out company to further develop their value proposition, with a view to either providing a service directly or exiting through a trade sale.

Very few academics choose the latter option. But those who do take this brave step need financial support and mentoring. Incubation centres such as the STFC/European Space Agency Business Incubation Centre in Harwell, and the associated funding available from Innovate UK through the Harwell Space Launchpads, offer an excellent model of how start-up companies can develop if they have a funding roadmap to facilitate growth and to support it in securing investment capital.

The Security Innovation and Demonstration Centre (SIDC)[3], launched by the Home Office in 2014, could provide another important incubation facility for forensic science. As an open innovation centre focused on security challenges, it will enable innovators to access end users and their environments for rapid real-world evaluation of new concepts, using a shared laboratory and demonstration space hosted at the Home Office's Centre for Applied Science & Technology (CAST). The SIDC aims to support start-ups through links to mentors and investors, thereby de-risking the introduction of new technologies. It will also host demonstrations to overseas delegations to

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support UK security exports.

More established companies typically decide whether to develop a new technology based on an assessment of strategic need, and the potential return on their investment. A purely commercial environment, where market forces alone drive the agenda, may hamper further development of an existing technique for several reasons. Some companies may be unwilling to invest in a new 'market leading' technology if the legal process requires that the methodology is disclosed, thus allowing other companies to develop rival products. Or they may wish to only employ members of staff who directly provide services (and therefore bring in income). As a consequence of these factors, in the future most commercial companies may not have dedicated research and development departments to bring through innovative new technologies or methods.

But innovation is not just about making breakthroughs or developing a novel invention. Incremental innovations are far more common, and result in improved performance for existing technologies. They may offer better accuracy or precision, lower the limit of detection, or improve reproducibility; or they can increase the throughput of an analytical process, or reduce costs. One recent example is the availability of commercial robotic auto-samplers that interface with gas chromatography-mass spectrometers, which now enable the majority of sample preparation and analysis to be performed automatically, without the need for skilled human intervention. However, the source of funding for such incremental developments remains an open question, especially as one moves further away from the market and the level of risk increases for the innovator.

OPPORTUNITIES FOR THE UK IN A GROWING MARKET

Some police services are now approaching universities to undertake research projects on their behalf. Regional meetings (e.g. in Yorkshire and the Humber) have allowed universities to present their capabilities and the possible analytical tools they have available, and for the police to present the problems they would like to investigate. A simple summary of what police services typically require is: "What we do now, but quicker and on site, please".

As part of its remit to enable closer networking and better communication between forensic science stakeholders, the FoSci SIG promotes an annual networking event called the Forensic Science Technology Showcase. The aim is to bring together funders and potential buyers so that innovators can showcase new technologies, in order to help them find a market[4].

Innovators can also make these connections through the Chartered Society of Forensic Sciences, which has members from all aspects of forensic practice, crime scene investigation, policing, military, medical, dentistry and legal professions[5]. It offers continuing professional development (CPD), scientific meetings (with CPD points), qualifications, social and networking events, professional recognition and scholarships. The society also provides an accreditation system for academic institutions that deliver forensic science undergraduate and postgraduate courses (see Chapter 2 case study p30).

The Association of Forensic Service Providers (ASFP) could also play an important role. It is an independent, representative body that seeks to facilitate the effective delivery of justice and promote public confidence in forensic science[6]. The AFSP was constituted on 1 July 2010 with a mission to represent the common views of the providers of independent (i.e. non-police) forensic science within the UK and Ireland, while maintaining and developing best-practice in forensic science and providing expert opinion in support of the justice system, from scene to court. As such, it could act as a single voice for FSPs in the UK and Ireland, help to share international best practice, and promote global market opportunities.