

Forensic analysts working within LGC Forensic's high sensitivity DNA profiling laboratory. Image courtesy of Andrew Brookes



CRIME FIGHTERS

Greg Blackman looks at the importance of LIMS in forensic laboratories, where test results can be crucial evidence in criminal investigations

The investigation into the rape and murder of two schoolgirls in Leicestershire, UK in 1983 and 1986 was a landmark case for forensic science. It was the first in which DNA profiling led to the conviction of the killer, local man Colin Pitchfork. Not only was the technique used to positively identify Pitchfork as the murderer, it was also used to exonerate one of the investigation's prime suspects, who in all likelihood would have been wrongly convicted for the crime if it hadn't been for the forensic DNA evidence.

DNA profiling was developed by Sir Alec Jeffreys at the University of Leicester. Jeffreys, along with Dr Peter Gill and Dr Dave Werrett of the Forensic Science Service (FSS), published the first paper on applying DNA profiling to forensic science – and, in 1985, were the first to demonstrate that DNA could be obtained from crime stains, which proved vital in the case.

A lack of leads and forensic evidence after the first murder in 1983 meant that the investigation was wound down, but a similar crime three years later in the same area led police to suspect that the attacks were carried out by the same perpetrator. Semen samples from both victims were analysed using DNA profiling and compared against a blood sample from the suspect at the time, which, consequently, proved their innocence.

The police then undertook the world's first DNA intelligence-

led screen, in which 5,000 men from the area were asked to provide blood or saliva samples, with the FSS carrying out DNA fingerprinting on the 10 per cent of men who had the same blood type as the killer. Pitchfork had paid a friend to give blood on his behalf, but the friend was heard bragging about this and Pitchfork was subsequently arrested. His DNA profile matched that from the semen from both murders and he was sentenced to life imprisonment in 1988.

DNA profiling is now an incredibly important tool for the police and the basis for several national DNA databases. The UK National DNA Database (NDNAD), for example, was established in 1995 and between April 2009 and 28 January 2010 produced 174 matches to murder, 468 to rapes, and 27,168 to other crime scenes. In the US, the FBI has established a similar database – the Combined DNA Index System (CODIS).

Forensic evidence is a vital part of any criminal investigation and forensic laboratories now provide a wide range of services, from DNA profiling, fingerprint and drugs analysis, to document investigations, forgeries, and firearms and ballistics investigations. As with other large laboratory operations, LIMS platforms are used to manage the throughput of samples and the results from analyses.

'For a forensic laboratory, the primary goal is that the reports created are fully reliable,' states Professor Kimmo Himberg, director of Finland's National Bureau of Investigation Forensic Laboratory (NBIFL). 'The chain of custody has to be unbroken throughout the examination process, because many of the reports will be used as evidence in criminal courts. We are able to ensure this with LIMS, which fulfils the requirements of our accredited quality system. At

every stage of the examination process, there are now acceptance procedures and only certain persons are entitled to accept each stage of the process.'

The Forensic Laboratory at Finland's National Bureau of Investigation (NBI), based in Vantaa, provides forensic services to investigative authorities across the whole of Finland. Forensic requests, or cases, are largely concerned with criminal investigations, with the laboratory tasked with providing hard, reliable, trustworthy evidence for the case. Its LIMS platform, christened LOLA, is based on LabVantage's Sapphire LIMS and is an important tool in providing this evidence.

The NBIFL handles approximately 30,000 cases each year, which equates to around 120 received from investigative authorities per working day. From these cases the lab receives around 150,000 to 200,000 samples per year. 'The difficulty with forensic work is that the samples can be anything from a single fingerprint to a car and anything in between,' comments Professor Himberg. The LIMS platform had to be able to deal with that variety of sample data.

Maintaining chain-of-custody

Tracking forensic samples and maintaining chain-of-custody is one of the key tasks carried out by LIMS. Tom Redmond, technical lead, C-LIMS programme at LGC Forensics, a privately-owned UK forensic science service provider, explains the process: 'In the first instance, samples are delivered to the labs as criminal exhibits. LIMS is used to manage the receipt, storage and the continuity of movement of the exhibits. We have to show the relationship between, for example, a jumper with a blood stain received at the lab, the material taken from the blood stain, and a specific sample within the laboratory. That sample then has to be tracked as it is processed within the laboratory and returned to its original storage location, and finally returned to the customer.'

LGC Forensics, a major division of LGC, is implementing LabWare LIMS to consolidate all of its existing LIMS and case management systems into one platform. LGC runs high-throughput analysis laboratories for DNA analysis, toxicology, and drugs or abusive substance testing, among other processes. These labs process up to 1,000 samples a day.

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LGC Forensics also has case work teams, which carry out more bespoke science looking at biological trace elements and other analyses. 'The lab processes are not as defined for these investigations and don't have a set procedure or method,' says Redmond. 'Therefore, rather than placing the emphasis on batching of samples and mass result processing, it's much more about managing the communication and the costing of the cases with the client. In some ways, this is moving into elements that would be seen more traditionally as ERP-type system processes, but managing those from within LIMS.' Aspects like generating financial statements or creating estimates for the client are now

managed by LIMS. LabWare LIMS has a forensics module within the core product, which handles bespoke case work. This provides specific case functionality, such as the ability to link multiple cases and to handle exhibits at a separate level within the system.

The labs apply a unique LGC Forensics barcode to incoming exhibits. Whenever staff members move an exhibit, they scan themselves, the exhibit, and the lab bench to track the sample as it is processed and note which analyst is carrying out the testing. The data is imported into LIMS to reflect the movement of the exhibit. 'We are then able to run a report that shows everywhere an exhibit has been. We're also able to search through the [LabWare LIMS] Storage Location Manager to see specifically what exhibits are in a particular storage location at a certain time,' comments Redmond.

'On top of this we've built up a hierarchy in which we're able to scan exhibits into packages,' Redmond continues. 'So we can put all of the exhibits for a case into a package and keep track of that package, while filtering down to the movements of the individual exhibits. Therefore, at any point the user can go into the system and search for an exhibit and see exactly where in the company that exhibit is, including if it is offsite or in transit to a customer.'

Colin Thurston, informatics, director of process industry strategy at Thermo Fisher Scientific, adds that LIMS has to be able to supply a complete audit trail of sample processing: 'The security and authentication of data is paramount to ensure that lab conclusions stand up to any legal scrutiny, hence a complete audit trail of sample processing events and electronic signatures are key requirements for the forensics LIMS.' Thermo Scientific's LIMS solutions have full auditing and electronic signature capability, as well as barcode support to enable error free sample identification.

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As with laboratories in many markets, LIMS is often interconnected to various other systems within and sometimes outside of the enterprise. Thurston notes that it is a key requirement for any LIMS deployed within forensic laboratories to integrate with a variety of additional systems in a closed and secure environment. High-throughput DNA sequencers, for instance, are often integrated into LIMS to gather the data automatically. Thermo Scientific LIMS provides a framework for sample management and data capture that is easily extensible for high-throughput labs with full integration capability with major analytical instrumentation, as well as external information systems.

One of the initial aims for the LOLA LIMS at Finland's National Bureau of Investigation Forensic Laboratory, which is based on LabVantage's Sapphire system, was that all the metadata associated with a case would be directly transferred from the Finnish police's nationwide data system to the laboratory's LIMS. The NBIFL has also introduced electronic reporting so that the laboratory reports are sent automatically from LIMS to the police data system, which, Professor Himberg notes, saves time and improves efficiency.

'ONE OF THE AIMS OF THE PROJECT IS TO REACH A STAGE IN WHICH WE WOULD BE WORKING IN A PAPERLESS LABORATORY'

'One of the aims of the project is to reach a stage in which we would be working in a paperless laboratory,' comments Professor Himberg. 'Of course, we will never be able to avoid the fact that the samples are material things and sample papers and identifiers will remain paper documents. But this is almost the only aspect not to be processed electronically.'

The laboratory instruments are almost all coupled with LIMS at NBIFL. The analysts also keep their laboratory notes in LIMS and all the case work is carried out in the system.

'We also wanted to make reporting of routine cases more efficient by introducing automated reports,' continues Professor Himberg. 'A vast majority of DUI [driving under the influence], drug and DNA reports, for example, are produced automatically by LIMS based on the analytical data.' The report is generated automatically through using standard sentences within the system. 'In the majority of our case reports, the scientists do not write anything anymore,' he adds.

The platform also provides NBIFL with a system to monitor and measure various stages of the analyses. 'It's a kind of management tool at the same time,' comments Professor Himberg. 'For example, the LIMS can provide data on the length of time taken to perform the various stages in each analytical test. Using that data we are able to identify, and potentially reduce, bottlenecks in the process.'

Professor Himberg hopes that, in the future, LIMS will act as a platform for developments in NBIFL's service concept: 'In the coming years we will be putting more effort into developing service products providing more support for the police at the crime intelligence and criminal investigation phase. Our reports will not only be produced simply as evidence to be used in court, but



LGC Forensics examiner recovering biological material from a hammer handle. Image courtesy of Andrew Brookes

also to aid ongoing criminal investigations.' Professor Himberg recognises that this means turnaround time for analytical results is much more of an important factor than before and analyses have to be undertaken faster. He adds that the laboratory and investigating police will have to cooperate and communicate more effectively. 'LIMS will provide the platform to enable these developments,' he says.

Redmond of LGC Forensics has similar grand designs for linking its LIMS into national forensic networks: 'In LGC's non-forensics divisions, results are published to web portals and the customer can book and order services through the web. In the forensics market there are more restrictions on using web portals because of the security of the data. However, we've moved the LabWare system into a high-secure domain with an eye on being able to link the system to a UK forensic network and serving our customers through that.'

The range of techniques used by forensic scientists has grown substantially since the mid-1980s when DNA fingerprinting came into effect and laboratories now must process large volumes of samples for a wide variety of analyses. LIMS and laboratory informatics remain vital for forensic labs to provide reliable, hard evidence for the police and authorities to build a criminal case.