AUTOMATION IN DNA ANALYSIS

Forensic laboratories are turning to automation to process DNA samples faster, and to better adapt to changes in the way DNA is collected in the field

Written by Dr. Barbara Llewellyn

Mark Squibb, laboratory supervisor of the Miami Valley Regional Crime Laboratory in Dayton, Ohio, prepares samples for a run on an automation workstation. Photo courtesy Miami Valley Regional Crime Laboratory

DURING THE LAST few decades, federal and state DNA collection and analysis systems have been highly successful in helping to solve and even prevent some of the United States' most violent crimes. However, this success has not been without challenges. The successes of forensic DNA analysis have resulted in a level of demand for service that has generated backlogs of unanalyzed DNA samples that laboratories have struggled to handle without adding more staff and equipment. The backlogs may never truly diminish—especially since DNA databases have mushroomed worldwide and submission of DNA samples of convicted offenders and arrestees into these databases has expanded tremendously. The current need is for these laboratories to obtain technology that will enable them to automate DNA sample testing so that they can streamline the forensic laboratory workflow and expedite validation and reporting of sample testing results.

LIMS Play Key Role, but More Needed for DNA Testing

Many of the 400-plus forensic labs in the U.S. have moved away from manual methods for executing laboratory operations and have instead adopted automated processes: robotic workstations, liquid handling systems, cell lysis sampling and sample pre-processing, and laboratory information management systems (LIMS) to automate evidence handling and casework management.

The aim is to improve the integrity and speed of evidence-handling procedures while ensuring proper chain of custody. While a LIMS is a major, powerful piece of this lab automation, it doesn't go far enough to address the more specific and urgent needs of DNA sample testing. What is needed is technology specifically designed for this type of testing that can be integrated with a LIMS. The push toward automated solutions for forensic DNA analysis allows laboratories to

avoid the potential pitfalls of manual solutions such as:

❏ Inability for swift error checking, resulting in delays in sample processing before moving on to other tasks.

❏ Inability to track samples and ensure their chain of custody.

❏ Cumbersome documentation process.

❏ Inability to prevent, track, and mitigate transcription errors.

❏ Inability for analysts/scientists to monitor their own workflow and for supervisors to track the workflow of the analysts who report to them.

❏ Slow throughput.

❏ Multiple data inquiries required with many sample processing systems.

❏ Time wasted in repetitive tasks, such as checking consumable lots and expiration dates.

❏ Difficult peer-review process.

❏ For multi-site labs, the requirement to travel to check or copy documentation prior to an audit.

Push to Automate Fueled by Agencies Wanting More Samples, Case Confirmation

Laboratory managers in particular are under pressure to streamline all facets of their laboratory's operations via automation, with DNA sample testing a high priority. In the last few years, thanks to the National Institute of Justice's passage of the DNA Backlog Reduction Program, federal funding has become available to help crime laboratories reduce and eventually eliminate DNA submission backlogs. The program is just one of several grant programs aimed at addressing backlogs by increasing efficiency, and pertains to database labs while other grant programs concentrate on casework laboratories.

The grant funding has enabled laboratories to automate as many operations as possible. Among these operations, automating DNA sample processing has become the new frontier. Commercial software, ranging from DNA sample testing modules (embedded within a LIMS) to standalone, specialized DNA-sample processing systems, is available.

Consider Your Lab's DNA Processing Needs Before Automating

It is important to understand your laboratory's specific DNA sample processing policies, standards, methodology, and throughput needs as you seek the right automated solution. Therefore, some key questions must be addressed. Here are a few questions for your laboratory to consider:

❏ What is your laboratory's present DNA sample and case backlog?

❏ How many cases and samples is your lab expected to complete each week or month?

❏ How many scientists, analysts, and technicians are on your staff to perform DNA sample processing?

❏ How much automation can you expect from the instruments you currently use?

❏ How many cases is your laboratory expected to complete each week or month?

❏ Do you need a sample processing software program that can handle both small and large volumes of samples?

❏ Are legislative changes likely to increase the number of samples to be tested?

❏ What instrumentation do you need to integrate?

❏ Does your laboratory presently use a LIMS and is it able to allow a DNA sample processing program to integrate with it?

❏ Does your laboratory have information technology support staff for DNA sample processing?

❏ Do you have a budget that can support the purchase of a DNA sample processing system as well as the necessary technical support and maintenance contract to accompany it?

❏ Is your laboratory seeking a standalone DNA sample processing system or a module integrated within a LIMS?

▲ *The batch setup module in a sample tracking and control program allows the user to allocate samples to batches. Image courtesy STACS DNA*

▶ *The "My Tasks" module in another sample-tracking program shows a user the current workload and provides a portal to access batches in progress. Image courtesy JusticeTrax*

The software is designed to more effectively test samples. The goal is to manage quality control from start to finish, to improve workflow and throughput, and to increase the number of DNA cases processed.

Clearly, laboratories become both more proficient and efficient in dealing with DNA cases once they have the right tools.

"Police agencies are becoming more reliant on labs to identify samples from crime scene evidence and to confirm their cases, and are more reliant on the CODIS database to help solve their cases," noted Jay Henry, immediate past president of the American Society of Crime Laboratory Directors (ASCLD). "For us (forensic laboratories) to keep up with rape kit testing, property crimes, and other DNA-evidence submissions, we need more staff and a lot more automation through robotics and software."

Automation makes the whole range of DNA processing methods more transparent and easier, Henry added. Equally important, he argued, is a need to train the law enforcement agencies submitting DNA-related cases to forensic labs for testing. They need to understand how to provide the right information and evidence so that a lab can begin a case, he said.

Testing Solutions Must be Flexible to Meet Specific Needs of Labs

Mesa, Ariz.-based JusticeTrax offers a standalone DNA application, called LIMS-Plus DNA, designed to reduce DNA backlogs by automating forensic sample processing for both casework and databanks. The software also can deliver DNA profiles to local, state, and national databanks. In addition, LIMS-Plus DNA is browser-based, requires no locally installed software, and will integrate with other applications. The Mesa (Ariz.) Police Department crime laboratory has used the original version of the software for several years, and is now testing the newest version released in 2014.

"JusticeTrax integrated some of our instrumentation in their DNA sample testing module," recalled Sarah Fredricks, forensic scientist III. "Through that integration, we have reduced transcription errors, increased efficiency, and reduced time overall in processing and entering profiles."

A huge advance in such software is that it gives forensic laboratories more flexibility with automating their DNA sample processing. That means the software can work based on lab scientists' needs for sample processing methodology. It's a huge change that gives laboratories more control and lowers the cost of software ownership. So, as to the Mesa P.D.'s ability to integrate instrumentation, "It does not require JusticeTrax to do this," Fredricks said. "It now can be done internally with administrators. And, most of all, JusticeTrax has allowed you to add new instrumentation without having to spend thousands of dollars for custom integration or enhancements. The way the product is designed, you don't have to completely change your process to conform to the product. It's more flexible, it can adapt to your workflow."

Browser-Based Software Facilitates Work with Data

According to Simon Key, president and owner of JusticeTrax, a browser-based DNA sample testing solution is essential. "It allows the laboratory to centralize all of its forensic biology data regardless of the distances involved," Key said. "You can now have a central database of forensic DNA information that really does not depend too much on how you've organized your laboratory. You can deliver DNA functionality over any IP-based network just by using the browser, but you only have to update it on a single machine." Key adds another advantage is that security access is built into a laboratory's Active Directory structure, and testing methods can now be customized.

Centralizing data is crucial, particularly for multi-site laboratories, according to Jocelyn Tremblay, president and COO of STACS DNA. How that is done is independent from the user interface. One option is using a browser; another is a client component, in which case a richer user interface is offered, minimizing clicks and mouse movement. Updates are easier, too, since software resides on the central server, not on individual workstations.

A browser is especially beneficial for data entry beyond the laboratory, and can be done when collecting convicted offender and arrestee DNA database samples.

Examining Return On Investment with Automation

Reducing the time it takes to complete DNA sample testing is the goal of any forensic DNA laboratory. STACS DNA has designed a tool that it claims any DNA laboratory can apply to its own situation. The tool was built after the company worked with forensic DNA laboratories such as the FBI, Royal Canadian Mounted Police, U.S. Army, and several large state DNA laboratories. STACS DNA asked customers to measure how much time they spent on specific tasks before and after implementing STACS-CW Enterprise, a sample tracking and control software solution for casework DNA laboratories. The return on investment (ROI) calculator tool was created as a result. "The cost of every task in a lab can be calculated in dollars and cents," Tremblay said. "Any lab should be able to calculate their expected savings based on a product's actual track record."

However, generating these kinds of ROI results may prove tricky regardless of software or any other tool, as they often are based on a snapshot in time, and measurement metrics can change even over short time periods.

Less Hands-On for Sample Testing

Reducing the hands-on element of DNA sample processing is key to any laboratory's ability to deal with the crush of cases requiring analysis and completion. That was the goal of Mark Squibb, laboratory supervisor of the Miami Valley Regional Crime Laboratory in Dayton, Ohio, when he decided automating sample processing was essential.

"In a DNA lab, you're kind of at the whim of the number of samples that come in," Squibb said. "Sometimes, you can get hammered by rush cases with large volumes of samples coming in under just one case. This can bog down a laboratory from turn-

ing cases around quicker so that they can manage the samples in a better way."

In 2010, Miami Valley Regional Crime Laboratory adopted the STACS DNA sample tracking and control software. As for capabilities, Squibb insisted the software must process low-volume DNA samples, which STACS DNA handles well. The laboratory processes just over 300 samples and completes more than 100 cases a month.

Squibb feels his software has streamlined DNA sample processing over the past four years, especially when it comes to reports. "We can run reports for an entire batch, make a PDF of the report, and that goes into each of the cases within that batch," Squibb explained. "We can also file case notes electronically."

Integration with a LIMS, Other Instrumentation Essential

Squibb believes that the success or failure of any sample processing software depends on the features it offers. When his lab adopted STACS-CW Enterprise, the main requirement was that the software automate the laboratory's workflow and deliver full integration with all instrumentation, its JusticeTrax LIMS, and CODIS. For example, Miami Valley Regional Crime Laboratory uses a TECAN robotic liquid handling workstation for processing casework.

"STACS is able to interact with the instruments we use and can run samples to be batch-specific," Squibb said. "This means that the samples that are on the TECAN workstation require specific components, and it needs to know how many samples will be handled and where they will go. The software will generate this information."

When the DNA samples are completed and it is determined which samples need to be put in the DNA database, entering these by hand at a computer took too much time—anywhere from an hour to all morning, depending on how many samples a person had. Instead, STACS DNA creates an electronic XML file that can be imported.

DNA Module For LIMS Provides Another Option

Another offering for automating DNA sample testing comes from Porter Lee Corporation, which has created a DNA module for its Crime Fighter BEAST LIMS. The DNA module works with the LIMS to enhance the DNA processing workflow. For example, the module's onscreen worksheets help forensic DNA laboratories organize their work. Instrument interfaces take worksheet and sample data directly to automation workstations such as the Tecan Freedom EVO, offering reliable liquid handling and easy-to-use robotics, and the Beckman Coulter Biomek 2000 that handles compound management and high throughput screening, in addition to liquid handling. Onscreen worksheets are instantly converted to plate-set-up files that are exported directly to instruments for quantification, amplification, and analysis protocols. Results from the instruments are easily imported back into worksheets. Overall, the Crime Fighter BEAST DNA module streamlines and automates sample data entry, screening, extraction, quantification, amplification, analysis, and the writing of final reports.

Rapid DNA Promising

Rapid DNA analysis, used to generate DNA profiles in less than two hours, has attracted increasing interest among forensic DNA laboratories. On December 1, 2014, the FBI updated their DNA databasing standards to include quality-assurance standards for Rapid DNA analysis. This change has opened the door for several manufacturers that have developed instruments for Rapid DNA analysis. The process consists of integrated extraction, amplification, separation, and detection without human

An examiner at the Kansas City (Mo.) Police Department Crime Laboratory loads a DNA plate onto a liquid handler robot. Photo courtesy Jennifer Howard, Kansas City Police Department Crime Laboratory

intervention, but requires human interpretation and technical review. One manufacturer, IntegenX, maker of the RapidHIT System, has met the requirements for CODIS upload. Accredited forensic laboratories can use the RapidHIT System to develop DNA profiles from crime scene samples and database samples provided they are compliant with the FBI Director's Quality Assurance Standards for Forensic DNA Testing Laboratories.

Rapid DNA systems are being tested and evaluated by the FBI Laboratory and several other Federal agencies, such as the National Institute of Standards and Technology (NIST) and the Army Crime Laboratory. According to its website, the FBI has been examining how to integrate Rapid DNA technology first into CODIS laboratory operations, then into police booking locations.

Automated Choices Cater to Laboratory Managers, Too

Although today's software offerings for DNA sample processing are well designed for the needs of laboratory scientists and analysts, they also cater to the desire of laboratory managers to ensure overall operations are at peak performance and productivity. Therefore, the software enables supervisors to check on the status of DNA samples being processed for any case. Both STACS-CW Enterprise and the LIMS-Plus DNA program from JusticeTrax, for instance, offer a "dashboard" that allows laboratory supervisors to view all DNA samples ready for extraction so they can monitor them from backlogs and determine how to refine the workflow.

Flexibility, Scalability at Heart of Sample Testing Solutions

Above all, because today's DNA realm is constantly growing and changing, any sample testing solution must be flexible and scalable. These are criteria that the Alaska Scientific Crime Detection Laboratory is carefully considering as it prepares to adopt a solution. The state crime laboratory is the only full-service crime laboratory in the state, with 42 employees, including ten DNA analysts, a DNA technical manager, and a DNA supervisor. Orin Dym is the forensic laboratory manager. "The push is to decrease the number of steps, the number of times the DNA sample is handled, which is good because that's where the drive in technology should be," Dym asserts. "You (the forensic laboratories) want to look at software systems that are robust enough to handle dramatic process changing breakthroughs that come out because what you're doing today may change next year."

A big part of Dym's decision on a sample testing solution was its ability to integrate with his LIMS. "I want my case files in one system, and I want the data transfer back so that the cases, notes, what we discovered, what we disclosed is always in the LIMS," he said.

Beyond that, Dym feels any DNA sample testing system must adapt to a forensic laboratory's specific needs and preferences. For instance, he offered, such a system should allow a DNA analyst to change chemistry kits used so that a new one can be added and the necessary fields will be provided. "You want to be making your best scientific decisions based on science, not because you're hardwired into a software package that can't be changed," Dym said.

Forensic laboratory personnel are seeing the benefits of comprehensive automation of processes in their operations. With emphasis on DNA sample testing only widening and sample backlogs growing, laboratories are realizing they must devote time and resources to DNA testing in particular. Choosing the right kind of automated testing solution is pivotal to streamlining lab workflow and strengthening chain of custody and the investigative fact-finding process as a whole.

Whatever solution is chosen, it must be scalable and flexible. After all, concludes Henry, the ASCLD past president, "Laboratories dealing with DNA are not static, they are dynamic. We've got to have technology that adapts to all of the changes occurring with DNA in the forensic laboratory." Furthermore, Henry added, "Increased throughput and productivity and getting cases out the door faster while maintaining quality are going to be your measure. Then you want to measure cost, which means you should see efficiency and productivity increase and your cost per case decrease."

About the Author

Dr. Barbara Llewellyn has been in the forensic DNA field for 24 years. She assisted in bringing STR analysis online at both the Virginia Department of Forensic Science and the Illinois State Police. She currently works as a private forensic DNA consultant.

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