HAMILTON

Optimizing Automated Storage of Forensic Samples at NFI

A Case Study with

Netherlands Forensic Institute
Ministry of Justice and Security

Overview

The Netherlands Forensic Institute (NFI) is one of the world's leading forensic laboratories, boasting expertise in over 30 different forensic disciplines. NFI strives to be the most innovative and customer-focused supplier of forensic products and services while strengthening the rule of law, both nationally and internationally. For years, NFI has remained at the forefront of developments by continuously investing in education and innovation. In doing so, NFI can both ensure the rapid development of new forensic research methods as well as respond to social, technological, and scientific developments within the industry.[1]

> **"Automation and digital technology play a very important role at the NFI. They allow us to increase our capacity, reduce our costs, and, which is very important in our work, avoid mistakes."**
>
> ***Professor Arian van Asten,*** *Director Science,*
> Interdisciplinary Research, Statistics and Knowledge Management
> (NFI Inside Out Extended Version Video, 2017, 1:15)

Introduction

One of the primary tasks of NFI's Division of Biological Traces is to perform DNA profiling on 50,000 to 70,000 forensic trace and reference samples each year. These samples are highly sensitive to cross-contamination and must be stored for up to 80 years, according to Dutch law.

DNA profiling is a process utilized by forensic scientists to assist in the identification of individuals, often used by NFI in criminal case studies. Typically, a reference sample is analyzed to determine an individual's DNA profile. Then, reference DNA profiles from suspects and convicts are uploaded in the national DNA database. Finally, DNA profiles obtained from trace samples, safeguarded from crime scenes, can be searched and uploaded to the national DNA database to determine whether they match with a reference sample.

NFI, which originally automated its workflow with BiOS by Hamilton Storage, was later in need for higher throughput capacity for automated tube picking in its laboratory process, along with new operational demands for additional automated storage at +4°C. The facility currently has a -80°C BiOS system, which serves as a long-term archive for DNA extracted from crime scene evidence stored in 0.7 mL screw cap tubes.

BiOS is a large-capacity automated -80°C sample storage and retrieval system, often used in biobanking applications. BiOS can introduce and sort samples, manage inventory, and process and deliver orders. In addition, BiOS records a full audit trail and temperature log for all samples managed in the system. Its modular and scalable design allows storage of 100,000 to over 10 million samples in a wide variety of tube types.

1. https://www.forensicinstitute.nl/about-nfi

Challenges

In addition to tubes, NFI also requires temporary storage for DNA extract and DNA storage cards in a secure and controlled, yet easily accessible, environment. This allows for the quick retrieval of samples during the profiling process based on LIMS ordering lists and automated business rules.

In forensics, it is vital to prevent the simultaneous processing of victim/suspect trace samples within a case. Additionally, it is necessary to limit human handling of samples during the process.

Samples are stored for up to 30 days before being transferred to the BiOS system for long-term archiving. NFI needed this temporary store to offer larger capacity storage and higher throughput in sample picking to meet demand, while also eliminating any risk of cross-contamination between samples.

150K
DNA Cards

80K
96-format
0.7 mL tubes

1.6K
AutoLys tubes

Solution

In order to overcome the unique challenges NFI was facing, the laboratory, with the help of Hamilton Storage, upgraded from a smaller storage system to a customized +4°C Verso M3 system, with the capacity to store 150,000 DNA Cards, 80,000 96-format 0.7 mL tubes, and 1,600 AutoLys tubes.

Verso is an automated sample storage system easily configured to meet the needs of the most demanding sample management applications. With its quick processing speeds, Verso allows more time to be spent on science instead of manual, labor-intensive tasks.

NFI's new Verso system allows the lab to manage and store three distinct sample types:

1. Forensic trace samples, collected in the AutoLys tubes
2. Liquid DNA extracted from trace samples
3. Reference DNA, which are buccal cells stored on DNA cards

Sample storage in forensic science necessitates high-level security. Verso fulfills this requirement by offering a dedicated user management system, which is used to restrict access and system functions—all sample movements are traced, complete with a full audit trail. Additionally, dedicated forensic labware such as 96-format tubes, AutoLys tubes, or DNA collection cards can be stored and picked in one system.

VERSO M3 SYSTEM
BY HAMILTON STORAGE

NFI's New Workflow

First, biological evidence material collected at a crime scene is placed into AutoLys tubes for evidence examination and trace recovery. The AutoLys tubes enable sample lysis and separation in a single, fully enclosed assembly. These tubes consist of a lid, inner tube with filter, and outer tube with 2D barcode.

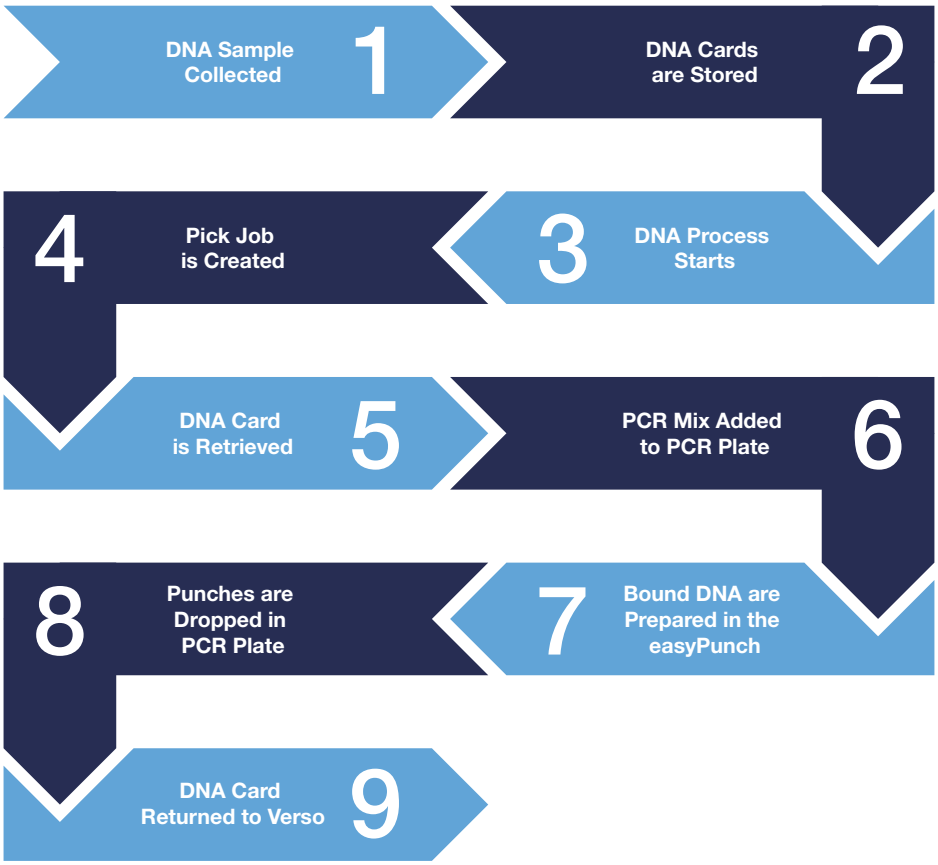
In automated workflows, the special tube design ensures stability during the lift-and-lock lysis process. Also, the 2D bottom barcodes are easily scanned from underneath the rack for traceability. These trace samples are then transferred to the Verso prior to the DNA extraction process.

Though it is uncommon to store AutoLys tubes, this particular process helps to automate the sample processing workflow according to NFI's business rules, stating that there must be separate processing of victim/suspect traces, as well as reference/trace samples.

NFI's Verso was also customized with special features to further comply with its business rules, including the ability to acclimatize DNA cards prior to output to avoid condensation and moisture uptake, and it has been fitted with a unique fire prevention system.

Reference DNA Process

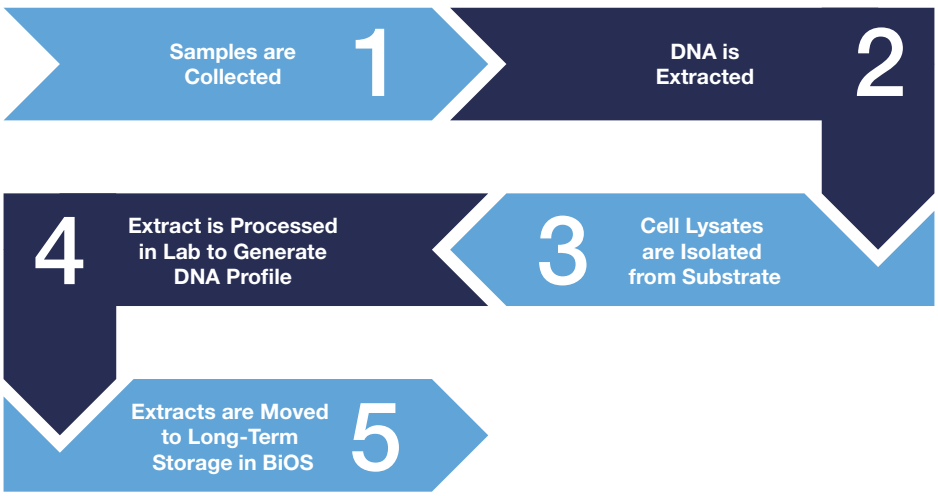
1. A high quality DNA sample is collected from a known individual. These samples are typically buccal cells, deposited on a paper substrate (Copan NUCLEIC-CARD™ [40U0300]). Samples are used for exclusionary purposes by comparing DNA profile with that of crime scene DNA profiles.
2. The DNA cards are then stored in NFI's Verso system.
3. When the samples are allowed to be processed for DNA profiling (legal authorization of processing), the DNA process is started.
4. A pick job is created in Verso's LIMS.
5. The DNA card is retrieved.
6. PCR mix for DNA amplification is added directly into the PCR plate.
7. Small punches of paper containing bound DNA are prepared in the easyPunch by Hamilton Robotics.
   - The easyPunch is designed to identify sampling area and punch specimens from an automation-compatible sample card into microplate wells and verify the specimen punch has been placed into the desired well of the plate.
8. Punches are then dropped into PCR plate.
9. The DNA card is returned to Verso (repeat of process is possible, if required).



VERSO PICKER
BY HAMILTON STORAGE

Crime Scene DNA Process

1. Samples, the quality of which can vary, are collected from traces/exhibits found at a crime scene and compared with reference DNA profile for identification purposes.
2. DNA is then extracted from these safeguarded trace samples.
3. AutoLys tubes are used to isolate cell lysates containing DNA from substrate.
4. Part of the extract (aliquot) is processed in the lab to generate a DNA profile and, while the rest of the DNA extract is temporarily stored in Verso at +4°C, a second aliquot is directly stored in BiOS at -80°C.
   - If a successful DNA profile is obtained on the first attempt, the DNA extract can be archived in BiOS at -80°C.
   - If a repeat analysis is required, the "master" DNA extract is retrieved from Verso for additional lab processing. The "master" DNA extract is then returned to storage at +4°C.
5. After 30 days, all DNA extracts are moved to long-term storage in BiOS. According to Dutch law, the extract must be kept for up to 80 years.



Summary

The addition of a Verso automated storage and retrieval system has optimized the DNA profiling process and, in doing so, created a one-of-a-kind workflow for the NFI; using the store not only as an automated picking component, but also an integral part of the *entire* DNA profiling workflow.

Using Verso as a temporary store and automated picking component guarantees that only samples allowed to be processed together during the wet lab process remain in the same batch throughout DNA extraction and pre- and post-PCR steps.

To ensure that the possibility of cross-contamination is virtually eliminated, NFI is using Verso's INSTINCT® S software to support implementation of its business rules for separate sample processing. Thanks to a special feature within the INSTINCT S software that allows the user to define a pick job based on a specific date or range of dates, Verso has the ability to flag DNA extracts that could be transferred to archiving. Additionally, the system is the first of its kind able to pick and place Copan NUCLEIC-CARDS.

The addition of this customized Verso is a prime example of how Hamilton Storage automated sample management systems can satisfy the needs of even the most demanding applications while also ensuring that laboratory processes strictly adhere to predefined business rules.

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