Document Title: **Evaluability Assessment of Cost Saving DNA Technology**

Evaluability Assessment of Cost Saving DNA Technology

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NIJ Guidance

The National Institute of Justice (NIJ) recommends an evaluation of cost saving DNA technology in the site assessed below (or other appropriate forensic laboratory settings). In particular, NIJ is interested in a retrospective impact and cost-benefit analysis of the West Palm Beach (or other locality) application of this technology. Applicants who propose to evaluate this technology are encouraged to consider outcome variables such as accuracy of identification, error rate, and processing time, as well as challenges (including issues related to external validity) identified below.

Applicants may depart from this guidance by providing appropriate rationale.

1. Technology Summary: The process of analyzing DNA for forensic evidence generally proceeds in five stages. In the first stage, the evidence is screened by a forensic scientist who attempts to locate DNA evidence, either by swabbing for DNA or by taking a cutting of the original material. In the second stage, DNA evidence is extracted with the assistance of DNA extraction technology which varies by laboratory. The third stage consists of quantification an analysis that yields an estimate of the amount of DNA that is present for testing. In the fourth stage, the DNA undergoes amplification where it is determined whether or not a useable profile can be obtained. Throughout the amplification process, a second DNA scientist acts as a reviewer, ensuring that no mistakes are made by the primary analyst. Finally, if a profile can be obtained, the sample undergoes a process of allele detection whereby the DNA is coded and subsequently compared to known samples in the CODIS database. If applicable, a report must be written, detailing the findings of the analysis.

The goal of the new technology is, to the extent possible, to roboticize the process of working with biological material to extract a DNA profile. As noted above, the process as currently practiced involves a significant amount of hands out processing of biological material as well as extensive duplication of effort in the review process. Adoption of roboticized processing is expected to reduce the burden on staff, minimizing error rates and create cost-efficiencies.

Currently the Palm Beach County Crime Laboratory uses a range of manual and semi-automated technologies to complete the DNA analysis process. The first stage, DNA screening is completed manually as the process of locating and gathering potential DNA evidence on submitted evidence varies considerably depending on the nature of the sample. In the second stage, the laboratory utilizes technology created by

BeckmanCoulter (Biomec 2000) to extract DNA and, in the third stage, quantification is conducted using the ABI-7000 which holds a 96-well plate. In the fourth stage, a MasterCycler is used to amplify DNA.

Scope of Evaluation: An impact analysis and a cost-benefit analysis should be undertaken to determine if the implementation of robotic DNA processing is more cost-effective and cost-beneficial than manual processing. Several options are available to do so. In West Palm Beach, much of the roboticization process has already been undertaken. It may be possible to implement a prospective pre-post design to test the efficacy of additional enhancements, especially the effectiveness of technology that has not yet been brought on-line. Otherwise, a retrospective pre-post design could be used to estimate the cost effectiveness of the processes that have been roboticized to date. West Palm Beach appears to have sufficient administrative records (not entirely automated) that would facilitate such an effort. An evaluation that compared West Palm Beach to other jurisdictions does not appear to be viable since the need to customize software and hardware limits external validity.

Summary of Evaluability Assessment Activity: The assessment of the feasibility of evaluating robotic DNA technologies began with a literature review and a Web-based search to identify vendors of such technology. The literature review and interviews with key stakeholders revealed that while some automation of DNA pressing is common in the field, there is little systematic application of these technologies. Indeed, some of the technology being employed in West Palm Beach are basically prototypes with no analogue in other jurisdictions. There is no available empirical literature describing the effects of robotic DNA processing technology.

Urban Institute staff verified that a site visit to West Palm Beach, which had been identified as a leader in applying this technology, was therefore warranted.

Finding: A retrospective impact and cost-benefit analysis of the West Palm Beach application would be possible. Several robotic processes have been implemented at the site, and sufficient data are available to facilitate such an evaluation. However, much of the required data are not automated, so a substantial data collection effort would be necessary. And, it is not clear whether the results would have sufficient external validity to inform practice in other jurisdictions. Robotic technology must be substantially customized and therefore contextual factors may limit the implications for other agencies.

2. Brief Literature Review

What do we already know about projects like these? Would this evaluation add to what we know?

Robotic technology has the potential to streamline the process of analyzing DNA simultaneously reducing the probability of human error that is intrinsic to the current state of practice. Currently, as DNA moves from stage to stage, DNA must be manually transferred between machines, which consumes valuable analyst time and provides an

opportunity for error to be introduced into the process. The idea behind robotic technology is that a given 96-well plate can be carried through each of stages two through five of the analysis, transferring the plate to a new machine at each stage. In addition, current technology can analyze only up to 5 ml of volume per sample. New technology would allow for up to 20 ml to be analyzed, which reduces the need to concentrate samples, thereby introducing increased potential for cost savings. Further efficiency gains are possible if the process is fully automated, allowing for the technology to obviate the need for a second reviewer. This has the potential to reduce the labor costs of DNA analysis considerably.

What audience would benefit from this evaluation?

The primary beneficiaries of such an evaluation would be local laboratories who would benefit from a rigorous analysis of the efficacy of these capital intensive purchases. In addition, a clearer accounting of the costs of DNA processing would benefit police and prosecutors. As the consumers of laboratory work, it is critical that these agencies have better information about the costs associated with processing biological evidence, so that more efficient decisions can be made about where and when to use these scarce resources.

3. Level of Site Cooperation

The West Palm Beach lab expressed interest in participating in an evaluation. There has been no formal evaluation to date and none is currently planned.

4. Background History

Robotic technology has been utilized by the West Palm Beach Forensic Laboratory for over two years. In 2004, West Palm Beach purchased and began using the Biomec 3000, a robotic system designed to transfer samples efficiently between each stage in the DNA analysis process. A small number of crime labs have adopted robotic technology. However, these early adopters are primarily large crime labs in major metropolitan areas. Moreover, the use of robotics has primarily been limited to the extraction phase.

5. Program Design

Target Population

The target population includes no-suspect cases where evidence is collected that may contain biological material. In addition, as DNA identification becomes more common, the technology may be used as a means of confirming other sources of identification, such as eyewitness statements or fingerprint identification.

Project Goals and Objectives

The automation is designed to both speed up the process (in terms of the time from when a piece of evidence is submitted to the lab to the time when a profile can be extracted) and to create more efficient processing (where more samples can be processed simultaneously). Increases in efficiency are the main goal of the processing. In particular, robots that are capable of generating reports will substantially reduce staff burden, especially as compared to manual processing which includes multiple stages of peer review. Secondarily, the processing may allow for additional suspects to be identified in two ways. First, robotic technology may allow for evidence to be identified that was not identified by manual processing (although there is little anecdotal evidence to support this idea, since the first step in the processing which identifies the presence of biological material is not yet subject to automation). Second, because more evidence can potentially be processed more quickly, it is possible that some evidence can be worked automatically that otherwise would not have been examined. This latter issue is more germane to the expansion of DNA identification to additional crimes rather than to better application of the technology to crimes currently subject to DNA identification. The technology also may reduce error rates, although there is little evidence that errors are common in manual biological processing.

6. Program Logic Model

Exhibit 1 presents the basic roboticized DNA processing logic model. The logic model is basically the same as the logic model used in manual DNA evidence processing. A piece of evidence (or pieces) are collected at a crime scene. The technology is then processed through the five steps described above. The logic of the automated processing is that it allows for more pieces of evidence to be processed simultaneously, and reduces the need for manual processing of evidence. As noted above, the manual processing of evidence is time and resource intensive, particularly the peer review processing.

The process is costly, as the capital expenditure on robots is large. In addition, the process of customizing the software and hardware to meet the requirements of a particular jurisdiction are also substantial. In addition, this process can take several months, and require senior staff attention.

Intermediate outcomes of the automated processing include measures of efficiency (greater numbers of samples processed per staff member). End outcomes include more DNA profiles obtained, more profiles obtained in shorter time period and fewer errors.

Is the logic supportable by empirical evidence?

There is limited empirical evidence to date to support these hypotheses. On one hand, there are data available from the lab to show that additional pieces of evidence have been processed due to automation (the lab estimates that processing time improved by 40% in the year after the adoption of robotic technology). And there is evidence that the processing is expedited. However, a careful study to determine whether these benefits outweigh the costs of the technology has not been undertaken.

Are there apparent contradictions or conflicts between certain activities and the outcome expected?

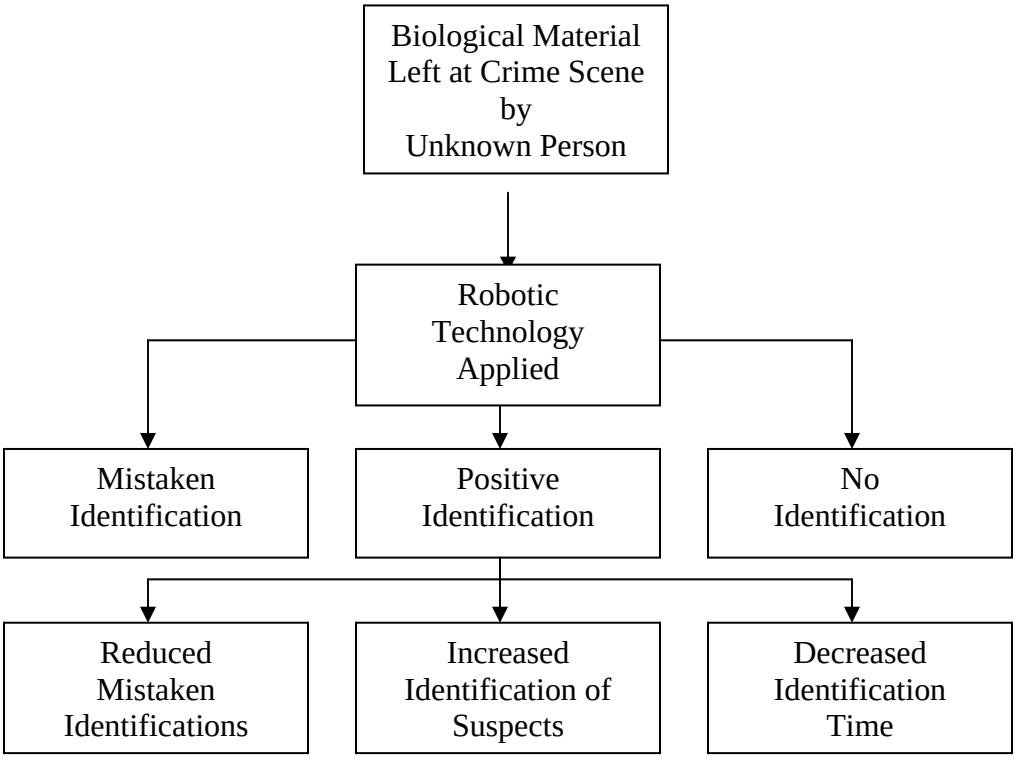
One substantial challenge of the test of this technology is the extent to which the successful application of the technology creates additional work which undermines the technologies effectiveness. For instance, in many labs with manual processing, there is a limit to the number of samples collected per case that can be processed by the lab (often set at two samples per case). Thus, the lab determines which samples are most likely to yield probative identification, and resources are focused on those samples. However, the effectiveness of DNA is accurately identifying subjects has led to pressure on labs to test all samples. Requests to have samples is driven both by an interest in identifying additional suspects if there are any, and, to minimize the appearance that someone other than the arrested suspect was involved. Thus, the West Palm Beach lab is required to test more samples per case and even with improved throughput it is not clear that the additional efficiency allows more evidence from more cases to be processed.

7. Implementation Issues

Is the project being implemented as planned?

The project is being implemented as planned. Robotic technologies have been purchased, customized and implemented in every day operations. Additional technology is undergoing assessment and customization. Additional technology purchases are being evaluated.

Exhibit 1 – Robotic DNA Identification Logic Model



Describe staffing

The West Palm Beach crime lab is headed by a crime labor supervisor (Dr. Cecilia Crouse) and contains eleven forensic scientists on staff. Each staff member is generally responsible for 120-140 cases annually.

Describe the stability of the project over time

The project is stable in the short-term. Robotic technology has been accepted as a routine part of case processing. Additional technology is anticipated. However, the advancement in robotic technology for use in DNA processing is advancing quickly and it is difficult to identify where the field will be in a few years, although it seems possible that advances will render current technology obsolete in a rather short period of time.

What aspects of the project could be evaluated for outcome?

Several research questions can be asked and answered using this data. First, what is the average cost per case (and per sample) prior to and after migrating to the use of robotic technology? Likewise, what is the cost per successful case outcome (extraction, profile obtained, database match)? Second, for a given level of expenditure, how many cases (and samples per case) can be analyzed both prior to and after the use of robotics? Does installation of robotics allow for more cases (and different types of cases) to be analyzed or is increased productive capacity used to test a greater number of samples per case? If the latter is true, is such a strategy cost-effective? Third, to what degree are the costs of the technology offset by benefits to society (in the form of reduced crime)? Fourth, to what degree has robotic technology reduced the rate of error in sample analysis? Finally, to what degree is this technology (and the relative effectiveness of the technology) transferable to other sites?

What would the outcome measures be?

Efficiency and effectiveness outcome measures would include time of case processing, number of profiles obtained, and error rate. Costs of obtaining the capital equipment could be studies, as well as the benefits of the technology, include the cost per case, cost per sample, and cost per DNA profile obtained. Aggregate measures of the total number of samples processed could also be measured.

How could an appropriate comparison group be created?

A retrospective pre-post design would be most appropriate for this evaluation. That is, the recent automated processing of cases could be compared to past practice where cases were primarily processed manually. Sub-group analyses isolating particular types of evidence (blood versus saliva for instance) or collection practices (CSI versus police).

Are the sample sizes statistically significant?

West Palm Beach processes a sufficient number of samples annually that there will be sufficient power to test both group and sub-group analyses.

Is random assignment possible?

Since all cases are processed using the same technology, a random assignment study appears to be infeasible.

Recommended Approach

It is recommended that NIJ support a retrospective pre-post comparison group design in West Palm Beach. Since the primary goal of this technology is to increase efficiency of processing, a cost-benefit analysis is also recommended.

Alternative Approach

An alternative approach is to identify one or more additional sites to implement a similar pre-post design. Given the small number of laboratories currently using these technologies, a sufficient number of sites to allow for pooled data analysis seems infeasible.

What strengths and weaknesses do the designs have?

Both of the efficiency and effectiveness designs suffer from the typical threats to validity associated with pre-experimental approaches. Their primary strength is the generation of knowledge on which to base future research efforts in an area where very little is known from a social science perspective.

How long in duration would the evaluation be?

It is estimated that the study of implementation, impact, and cost-benefit analysis could be completed within 18 months. A prospective analysis would require several additional months. The primary challenge to the evaluation would be to collect and manage the substantial data on case processing that is not currently automated.

What would be the estimated cost?

A pre-post study of automated DNA processing is estimated to require $150,000. Substantial time and effort would be required on-site to collect and record non-automated data.

What aspects of the project make an evaluation more difficult?

8. Measurement Model

Measuring the causal impact of robotic technology is complicated by the fact that temporal changes in the pattern of offending or in crime lab staffing may confound the main effect in a retrospective pre-post design. Since robotic technology has already been introduced it is not possible to randomly assign cases to different types of processing.

9. Data

Comment on the quality and availability of project-generated data to support these measures.

The Palm Beach County Crime Laboratory and stores a great deal of data about the samples they process and the data are housed in flat files that are easy to procure and analyze. For each case analyzed, the laboratory keeps track of the following variables:

- Lead DNA analyst
- Type of crime
- Number of samples submitted per case
- Number of items tested per case
- Number of strains per item tested
- Number of extractions
- Number of samples concentrated
- Number of profiles typed
- Number of database matches

Each case is identified via a case number assigned by the forensic lab and, if necessary, can be linked to a case number utilized by police and court agencies to track case outcomes. Though electronic data are available only for the past several years, paper records are available going back until 1993.

Because differences in patterns of offending as well as forensic laboratory practices differ markedly between sites, a cross-site comparison would likely be confounded in a multitude of unobservable ways. Moreover, only a very small number of forensic labs utilize the technology in question at this point in time. For this reason, any study of the viability of this technology will need to compare outcomes after 2004 to pre-2004 outcomes within the West Palm Beach forensic lab. To the extent that such a comparison is not obfuscated by temporal effects in the rate and pattern of offending or by personnel changes in the forensic lab over this time period, such a comparison is expected to yield valid estimates of the differential cost and quality of DNA processing with and without robotic technology.

In order to estimate the cost of DNA analysis, an evaluator would need to conduct semi-structured interviews with key staff at the West Palm Beach Forensic Laboratory

Can services delivered be identified?

Delivery of services is not an element of this technology application.

Can target population be tracked over time?

As unique identifiers allow case processing outcomes to be linked to subsequent criminal justice outcomes, a full cost-benefit analysis can be conducted.

Would an evaluation have to generate new or additional data?

New data might have to be entered electronically if a decision is made to evaluate forensic processing prior to 2004, where only paper records are available. In order to link case processing outcomes to criminal justice system outcomes, it will be necessary to collect data from additional sources.

10. Summary Remarks

Recommendations for evaluation

It is recommended that a pre- post- outcome design be employed by NIJ, where DNA processing outcomes are compared prior to and after the adoption of robotic technology. Sufficient data exist answer key research questions regarding the cost-effectiveness, and, with the addition of new data, the cost-beneficiality of robotic technology.

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