INCREASING EFFICIENCY IN A DNA UNIT USING LEAN SIX SIGMA

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ABSTRACT

The number of DNA requests received in many public crime laboratories has increased such that backlogs exist and turn-around-times are extended. Louisiana State Police Crime Laboratory (LSPCL) saw a 22% increase from 2006 to 2007 in the number of DNA requests submitted. The completion rate was not increasing at a rate to compensate for the increased submittals nor could the completion rate eliminate the backlog of requests that had accumulated. Turn-around-times exceeded a calendar year.

The Efficiency Improvement Grant provided the tools needed for LSPCL to change the technical workflow of DNA forensic analysis which allowed the backlog to be greatly reduced, case turn-around-time to be reduced, and productivity increased, such that LSPCL can complete 100% of the DNA requests that are received each month. Management of the administrative work within the DNA Unit has also been changed to ensure that the capacity of the laboratory is maintained and no new backlogs are created.

LSPCL hired external consultants and engaged in several projects aimed at solving the current state problems and changing processes to ensure continued success. Through the development of Lean Six Sigma (LSS) methodology, these projects achieved all goals set forth and has led to a culture that is client driven, quality focused and efficiency minded. The methodological approach applied is called LSS. LSS is the unique combination of Lean thinking and Six Sigma process improvement to form a thorough and comprehensive approach to quality improvement, process improvement and the elimination of waste to produce a remarkably efficient and quality driven product. The combination of Lean thinking and Six Sigma variation reduction, when merged together, forms seven guiding principles. The principles are (1) focus on the customer, (2) identify and understand how the work gets done, (3) manage, improve and smooth the process flow, (4) remove non-value added steps and waste, (5) manage by fact and reduce variation, (6) involve and equip the people in the process, and (7) undertake improvement activity in a systematic way. DMAIC is the acronym that describes the seventh principal. It is a systematic improvement framework, and it is the framework that the LSPCL and consulting teams followed to make dramatic efficiency improvements. DMAIC stands for Define, Measure, Analyze, Improve and Control. LSS can be applied to any process or any industry. LSPCL used this methodology to enhance the technical scientific process. The DMAIC steps guides the improvement process through specific activities. Using the DMAIC steps ensures that the customer's needs are met, quality is maintained, and goals are achieved.

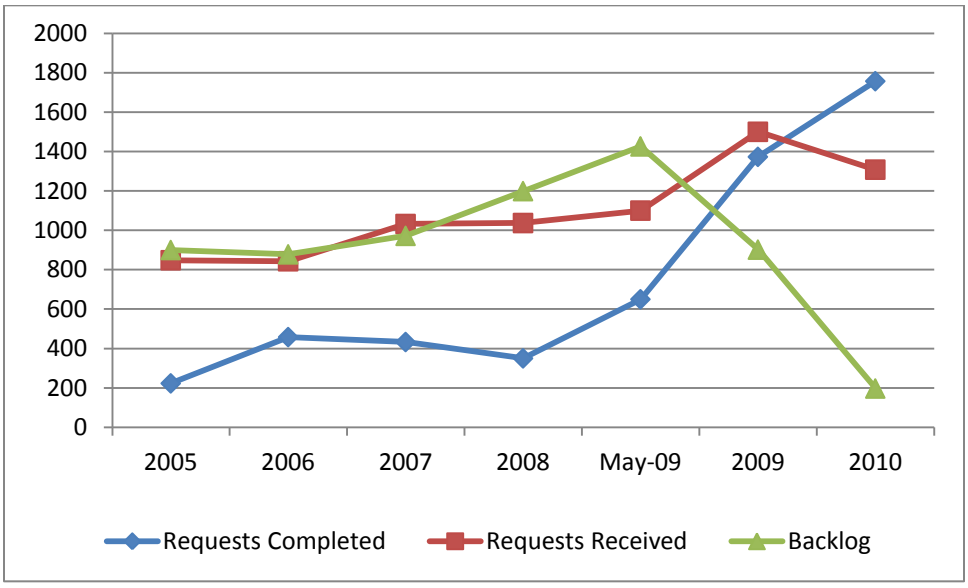
As of June 2011 LSPCL has decreased its turnaround time from an average of 291 days in May 2008 to an average of 31 days with 95% of DNA requests completed within 30 days. LSPCL has tripled the productivity from 50 cases per month to 160 cases per month. The backlog has decreased from approximately 1400 cases in May 2009 to 120 resulting in a re-classification of the terminology "backlog." Backlog is now described as any active cases greater than 30 days received into the laboratory. Total queue time decreased from 181 days in May of 2010 to 5 days. Additionally, the number of samples completed per month has increased from 312 in 979 with an average number of cases completed per analyst per month increased from 1.9 to 11.5 cases.

LSS methodology gives the user the necessary tools and a process that provides rapid and sustained improvements for technical or administrative processes. LSS was, and continues to be, a powerful management tool in the DNA forensic operations of the Louisiana State Police Crime Lab. With turn-around-times of <30 days, a workflow that allows a DNA forensic request to be completed within 6 days, the capacity to work all cases submitted each month, and a backlog that is eliminated each month, LSS has proven its ability in the forensic laboratory. The methodology allowed LSPCL to meet all project goals and has afforded increased operational efficiency and increased quality and service to the agencies served. The real-time support provided to investigations is helping solve crimes and is thereby making the citizens of Louisiana safer.

PROJECT

While Louisiana's overall violent crime and murder rates are decreasing, Louisiana's violent crime and murder rates are still one-half times and nearly twice the national averages, respectively (Nelson, 2010). The violent crime rate, combined with a recidivism rate of 67% (Hunter, 2010 and 2011), emphasizes the need for rapid investigational support to provide potential resolutions for criminal cases. In 2009, the rate of case requests being submitted to the Louisiana State Police Crime Laboratory (LSPCL) far exceeded the laboratory's capacity to report cases and to provide real-time support during the critical initial phases of an investigation. LSPCL saw a 48% increase from 2008 to 2009 in the number of DNA requests submitted. Additionally, as illustrated in Figure 1, while the completion rate was increasing (34% to 92% from 2008 to 2009), it was not increasing at a rate to compensate for the increased submissions and the accumulated backlog. The total backlog of the laboratory climbed to 14,500 requests (1425 for the DNA unit). With the time for completion on cases, (commonly referred to as turnaround time- TAT), exceeding a year, cases remained un-worked and unsolved for unacceptable lengths of time. In short, investigations were NOT being supported by forensics in a timely manner.

Figure 1
DNA Backlog and Request Received and Completed



The LSPCL has worked diligently to provide comprehensive countermeasures to the increasing backlog through the services offered to law enforcement agencies, the judicial system, victims, their families, and the public at large. After researching backlog approaches by other laboratories throughout the nation, the LSPCL adopted a backlog reduction strategy that was multi-faceted and innovative. The approach included enhanced governmental financial support; improved communications with agencies

served; leverage of technology resources; development of partnerships in hiring personnel through Memorandum of Understanding (MOU) agreements with other law enforcement agencies; increase efficiency and a change in culture through the adoption of Lean Six Sigma (LSS) business production and management theories. LSPCL engaged in this project to accomplish goals aimed at eliminating the backlog, reducing the TAT of cases by 50%, and doubling the productivity of forensic DNA casework; thereby providing increased CODIS generated leads to these cases. This project has allowed the LSPCL forensic DNA unit to provide results in a timely manner, thus providing real-time support to active investigations.

Funding afforded by the Louisiana State Legislature and Governor, the National Institute of Justice (NIJ), and the Office of Justice Programs provided several opportunities for enhancing the capacity of the laboratory such as – replacement of outdated equipment, purchase and validation of robotic equipment, the outsourcing of over 1000 backlogged DNA cases, and consultants were hired to guide the staff in implementing LSS methods. In addition to state support to increase permanent staff positions at the crime lab, state and grant funding supported temporary positions, hired short-term, to address priority projects.

Realizing that communication was essential, meetings were held with the laboratory's largest customers that included district attorneys and investigators to improve the effectiveness of working relationships. Agencies were asked to evaluate backlogged cases, identify cases that had been solved, closed, or no longer required DNA analysis, and to set priorities for the laboratory to ensure that the laboratories' efforts were focused on active priority cases. In return, the laboratory committed to applying added resources to working the higher priority (violent offense) cases first. An evidence receiving policy was developed and agencies were quickly instructed on the new standards of submission. The policy required submission of appropriate reference samples, written permission to consume DNA evidence, and a prioritization of evidence being submitted. Laboratory submittal forms were revised to require agencies to provide additional case related information. Also, an additional DNA specific submittal form was instituted to convey to the LSPCL the five most probative items along with a standardized Letter of Consumption form. One-on-one consultations during submission of cases by a DNA analyst for completeness and acceptability of the submission were instituted. This policy allowed for a more strategic and streamlined approach to DNA testing.

Use of technology expanded at the LSPCL. Desktop scanners were provided lab-wide, and electronic scanning of documents to the Laboratory Information Management System (LIMS) began to replace paper copies. Submittal forms are now scanned at the time of case submission, pictures are digitally attached, and reports are issued electronically to agencies for instantaneous access. Electronic recording through the LIMS system of nearly every task of the laboratory has been developed, including administrative functions such as legal requests and Combined DNA Index System (CODIS) hit notifications.

The LSPCL has developed partnerships with its agencies to increase personnel utilizing MOU agreements. These agreements enabled four full-time DNA analysts to be trained and work at the LSPCL, but salaries and benefits are paid by the law enforcement agencies they serve. This allows the law enforcement agency to directly provide personnel support, without the overhead of operating expenses such as facilities, accreditation, and supply costs.

The final facet and the cornerstone of the backlog reduction strategy was sponsored by the NIJ's Forensic DNA Efficiency Improvement Grant which provided the mechanism that has changed the culture at the LSPCL. A central focus of the grant proposal was based on the implementation of LSS business production and management theories. Implementation of these theories provided a platform to a goal oriented, accountable, efficient process that enhanced the efficiency of the newly obtained equipment, personnel and available resources. "Lean" is a concept from Toyota Corporation and refers to reducing process steps to only those that are essential and necessary: the elimination of waste. "Six Sigma" is a concept from the Motorola Corporation and refers to a business management strategy that seeks to improve the necessary steps, while improving quality. The combination of Lean thinking and Six Sigma variation reduction, when merged together, form seven guiding principles. The principles are (1) focus on the customer, (2) identify and understand how the work gets done, (3) manage, improve and smooth the

process flow, (4) remove non-value added steps and waste, (5) manage by fact and reduce variation, (6) involve and equip the people in the process, and (7) undertake improvement activity in a systematic way.

A team of seven managers and forensic scientists from the LSPCL worked with Sorenson Forensics, LLC and their Six Sigma Master Black Belt consultant along with other key stakeholders including LSP Administration and the LSPCL's main law enforcement and judicial customers. The team met a total of twenty-nine days over the course of five months. A project timeline and tasks schedule was developed (Table 1). A defined sequence of steps, known as DMAIC, allowed the team to Define the processes, Measure the current state, Analyze the data to decide which areas could be improved, implement the targeted Improvements, and then to Control or sustain the improvements.

During the Define phase, project goals which stated objectives and performance measures were developed, along with a Project Charter which defined team members' roles and the scope of the project. Suppliers, Inputs, Process, Outputs, and Customers (SIPOC) charts were developed for the LSPCL DNA case process (Table 2) to aid in a high-level understanding of the scope of the current process. An important element of the define phase is the creation of a current state process map that visually shows the tasks and decisions involved in a process. For this project, a process map of the standard operating procedure was developed in which the twelve major steps of the process and the major functions under each step were identified. Finally, a current state Value Stream Map (VSM) was developed that depicted the flow of cases and information through the laboratory.

The Measure phase of the project consisted of evaluation of the current processes to establish a baseline performance. The VSM was populated with the current state of cases and data for concepts such as TAT, total queue time (waiting to be worked), total process time, value added time (amount of time spent performing actual tasks), non-value added time, and number of cases in progress (WIP). Current state spaghetti charts were created to graphically illustrate the physical movement of people and evidence throughout the laboratory. Processes that have not been streamlined are often poorly laid out resulting in a longer path for processing. For example, it takes approximately 1 second to travel 2 feet. A typical sexual assault case traveled 12,687 feet or 2.4 miles (Figure 2)! The time to travel this distance is 106 minutes. The motion waste of this process was calculated to be approximately 34% of an employee's work year.

Table 1
Project Timeline and Tasks Schedule

March 5: Conference call with LSPCL Project and Consultants to initially discuss the project.

April 20-22: Define Phase: Orientation and assessment of the LSPCL DNA process, its goals and its challenges. Introduction of the DMAIC process, including the concepts of Six Sigma, a waste factory, SWOT analysis, organizational effectiveness, project charter, process map, spaghetti charts, SIPOC chart, value stream map and Gemba walks.

May 4-5: Measure Phase: Tollgate presentation of Define phase. Stakeholder meeting. Begin Measure Phase.

May 11-12: Measure Phase: Concepts discussed include TAKT time, percent load charts, 7-ways, 5-whys tree diagram, story board, balanced scorecard, CTQ tree. Kaizen event to eliminate review backlog was initiated.

May 25-26: Analyze Phase: Tollgate presentation of Measure phase. Kaizen event to eliminate review backlog. Concepts discussed include management system, leading/lagging indicators, S&OP schedule, and leader standard work.

June 8-9: Improve Phase: Continue to eliminate review backlog. Begin discussion on building a Future State Map with emphasis on waste reduction / elimination. Start to get entire DNA staff involved in the process. Begin cultural change.

June 22-23: Improve Phase: Continue to eliminate review backlog. CTQ Tree peer review process map discussion, continue to design future state map, level load charts.

June 28-30: Improve Phase. Define needs for an effective IT solution in the DNA lab. Build future state map.

July 20-21: Improve Phase: Discussion about leadership behaviors, including Herzberg motivation theory, head-hand-heart concept, 5S, PDCA cycle, S&OP schedule. Choreograph the Pilot. Pilot of future state process starts on July 26.

July 27-28: Improve Phase: Review days 1 and 2 of the pilot – the *good, the bad and the ugly*. Make changes, improvements and tweaks. Leader standard work discussion, case triage discussion, begin "comments sheets" to capture problems/issues.

Aug 10-11: Improve Phase: Aug 9 was start of week 3 of pilot. Debrief first two weeks of pilot.

Aug 24-25: Improve Phase and introduce control phase: This phase confirms that the proposed solution will meet or exceed the quality improvement goals of the project.

Sept 8-9: Control Phase: Once the project is closed it is not over. If process performance strays out of specification, immediate corrective actions occur to re-adjust and re-monitor to ensure there has not been an over-adjustment.

Sept 20-21: Control Phase continued.

Sept 29: Presentation of final report to all stakeholders.

Table 2
SIPOC

Suppliers	Inputs	Process	Outputs	Customers
Law Enforcement Agencies Investigators District Attorneys Defense Attorneys Supply/Consumable Vendors	Case evidence & case information Scientific methods, policies and procedures and training Manpower = analysts, technicians, managers, administration, purchasing, warehouse, evidence receiving dept. Compliance – safety, accreditation, inspections, audits, standards Reagents, supplies, equipment	1. Evidence Received 2. Triage 3. Screening 4. Digest & Purification 5. Quantification 6. Normalization 7. Amplification 8. Genetic Analyzer 9. Data Review & Interpretation 10. Report Writing 11. Review 12. Evidence Return	DNA Scientific Analysis Report Returned evidence and stored retained evidence Expert Testimony	Accurate TAT < 60 days Customer Service Professional, timely expert testimony Support during case challenges

Figure 2

Spaghetti Chart of Motion of a Sexual Assault Case

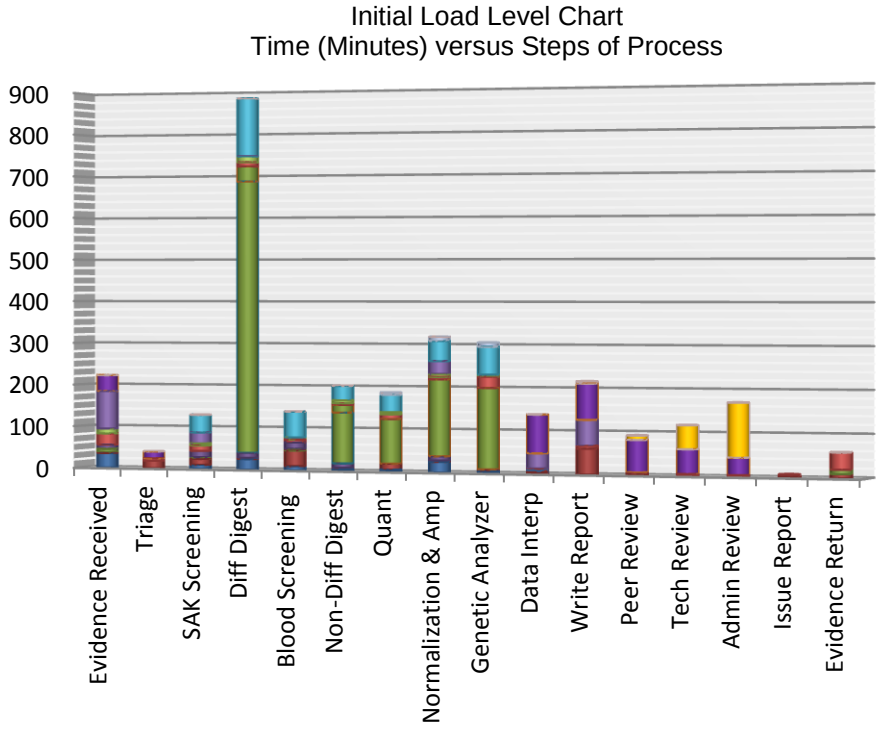
Initial Process Motion

Improved Process Motion

The Analyze Phase focused on analyzing the data collected during the Measure Phase and investigating the causes of the problems, bottlenecks, backlogs and defects uncovered during the previous two phases. Daily Production Meetings were implemented to discuss daily progress and workflow. These Daily Production Meetings continued throughout the remainder of the project and have become a permanent activity. The majority of the analyze phase involved the construction of a Level Load

Chart (Figure 3) to help create flow throughout the laboratory. Leveling is the smoothing of the volume of production in order to reduce variation and keep a consistent flow. Leveling of work was accomplished by batching a difficult homicide case with two sexual assault cases and several simple burglary cases. This batching or triage system roughly matched the mix of cases received in the laboratory. Crimes against persons were given priority. From these data, a new system was designed so processes could be grouped or additional personnel could be added to make all the processes take a similar amount of time.

Figure 3



The Improve Phase involved three distinct segments: (a) generate ideas about possible solutions, (b) select the most appropriate solution and (c) plan and test the solution. Three months were spent designing (new laboratory process), building, and implementing solutions. Improvements in the process included the relocation of laboratory processes and equipment to reduce motion waste, implementation of standardized workstations which included point-of-use storage of reagents and equipment, removal of unnecessary procedural steps, and a master hour-by-hour schedule was implemented along with a three week schedule of a proposed casework cycle. A pilot study utilizing the improved process was performed. The process consisted of four technicians, acting in a support role, and teams of three DNA analysts performing DNA analysis on batches of 8 – 10 cases in a five day production cycle. As a result of the initial pilot study, the DNA process has become a choreographed schedule of activities that are continuously monitored and improved via visual control boards (Figure 4).

The last phase of DMAIC is Control; the processes were controlled to ensure continued level of quality and productivity. The control phase enabled the laboratory to put in place a Management System to continually monitor its output and adjust operations when the data indicated or when the customer's requirements changed. One of the most important aspects of the control phase is visualization of current process and performance measurements. Daily production meetings occur between staff and management to report on progress, obstacles encountered, and identify opportunities for improvement. Weekly updates of ongoing projects are presented. All staff members are held accountable for their progress and take ownership of resolving issues that are encountered. Data such as samples processed,

cases received and completed, backlog, TAT, and status of unassigned priority cases are tracked visually on a daily, weekly, and monthly basis and analyzed for a constant, smooth output (Figure 5).

Figure 4
Control Boards

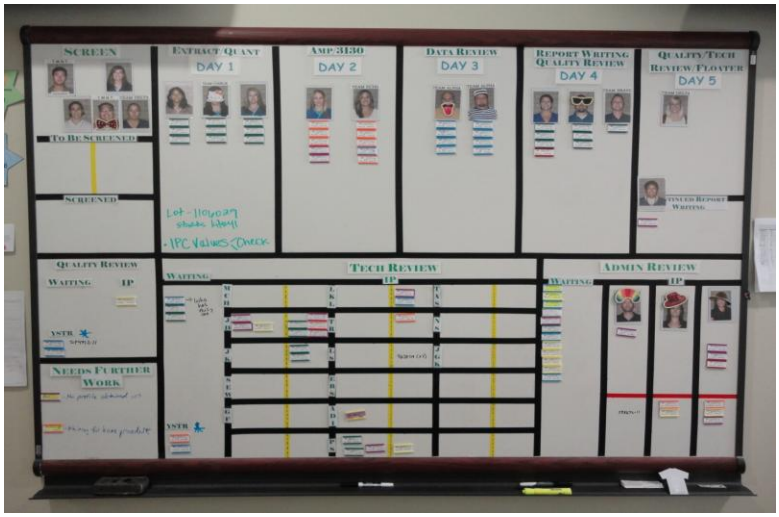
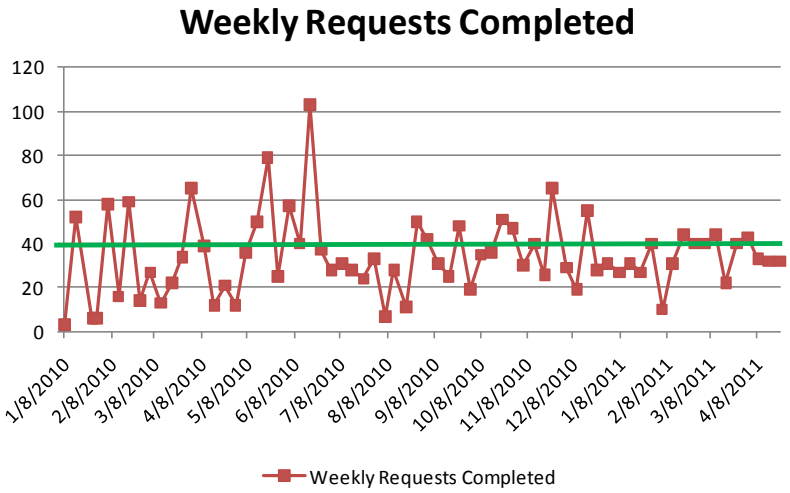


Figure 5



The LSPCL engaged in the Backlog Reduction Strategy project to accomplish goals aimed at eliminating the backlog, reducing the TAT of cases by 50%, and doubling the productivity of internal forensic DNA casework; thereby, providing increased CODIS generated leads to aid investigations. Today the LSPCL DNA Unit case completion rate exceeds the number of requests that are submitted each month. The increased efficiency from the implementation of this Backlog Reduction Strategy has led to elimination of the DNA Backlog (1425 cases in May 2009 to approximately 130 active cases currently with < 8% greater than 30 days old) (Figure 1) and decreased the TAT by 90% from 186 workdays to 20 workdays which exceeded the goal by 40%. In August 2010, seventy-two violent offense cases were waiting for analysis, whereas today analysis begins within days of evidence submission. Internal forensic DNA productivity increased approximately seven-fold, from 28 cases completed in May, 2009 to 192 cases completed in August, 2011. Streamlining of the physical layout of casework analysis decreased transportation/motion of a sexual assault kit from 2.4 miles to 1.5 miles (Figure 2). CODIS generated investigative leads have increased from 447 in 2008 to 735 in 2010.

Due to the success of the project, the agency has trained additional staff to be LSS leaders of other projects to systematically reduce waste and increase efficiency throughout the Louisiana State Police Crime Lab. The Narcotics Analysis unit's implementation of LSS has shown an initial 43% increase in productivity. The laboratory's overall backlog of 14,500 has decreased by 67% and the backlogs in CODIS DNA and print processing have also been eliminated. A Lean Six Sigma project was also undertaken in the Business Unit and is showing promise to save many thousands of dollars on normal operating expenses, while shortening the delivery time on supplies and equipment. The Lean Six Sigma projects have caught the attention of senior Public Safety management and they are currently initiating projects in other sections of the department. All of the improvements and reductions were accomplished while maintaining the highest standards and focus on quality. It is also noteworthy that LSPCL successfully transitioned to the ASCLD-LAB/International Standards during this timeframe.

The increased efficiency and effectiveness of operations has enabled the LSPCL to actively support ongoing investigations during the initial critical phases of the case. This real time support has been described as one of the most critical components of the newly established East Baton Rouge (EBR) Violent Crimes Unit (VCU), a permanent multi-agency investigative workforce, housed at the Louisiana State Police. The EBR VCU Initiative is an outgrowth of many cooperative efforts in the Metro Baton Rouge area to successfully investigate, apprehend, and prosecute persons committing violent crimes with active support from the LSPCL. The VCU and the LSPCL have collaborated in solving several high profile crimes and is quickly making a difference in the public safety for the citizens of Louisiana. The LSPCL has effectively utilized resources, improved communications, and thus provided enhanced forensic capabilities by providing real-time support to law enforcement and judicial agencies through this creative and innovative Backlog Reduction Project.

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