Laboratory Information Management Systems for Forensic Laboratories: A White Paper for Directors and Decision Makers

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EXECUTIVE SUMMARY

Modern forensics laboratories need LIMS implementations that allow the lab to track evidentiary items through their examination lifecycle and also serve all pertinent laboratory personnel.

The research presented here presents LIMS core requirements as viewed by respondents serving in different forensic laboratory capacities as well as different forensic laboratory environments. A product-development methodology was employed to evaluate the relative value of the key features that constitute a LIMS, in order to develop a set of relative values for these features and the specifics of their implementation. In addition to the results of the product development analysis, this paper also provides an extensive review of LIMS and provides an overview of the preparation and planning process for the successful upgrade or implementation of a LIMS.

Analysis of the data indicate that the relative value of LIMS components are viewed differently depending upon respondents' job roles (i.e., evidence technicians, scientists, and lab management), as well as by laboratory size. Specifically, the data show that:

- Evidence technicians place the most value on chain of evidence capabilities and on chain of custody tracking
- Scientists generally place greatest value on report writing and generation, and on tracking daughter evidence that develops during their analyses.

- Lab Managers place the greatest value on chain of custody, daughter evidence, and not surprisingly, management reporting capabilities.
- Lab size affects LIMS preference in that, while all labs place daughter evidence tracking, chain of custody, and management and analyst report generation as their top three priorities, the order of this prioritization is size dependent.

The following tables present a summary of the analyses in the larger paper.

Aggregate Response: Importance of LIMS Abilities

	Total
Daughter evidence	8.82
Management and Analyst Report Preparation	8.31
Chain of Custody Transfer	8.00
System Command Navigation	6.50
Generation of Analyst Summary Statistics	6.19
Pre-logging	6.07
Data Entry	6.01
Case Prioritization	5.51
Screen Manipulation	5.18
Case Evidence Status	5.15
Court system status	5.13
Case Grouping	5.08
Query Access to Management Data	4.77
Interface with analytical equipment	4.43
Terminal Mobility	4.13
Analyst Assignment	4.12
Asset Management	3.34
Personnel Certification Management	3.26

Ideal LIMS Based on Aggregate Response

- Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case
- High level of Data Entry automation
- When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes
- Supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation
- The LIMS allows analysts to create or access Summary Statistics showing performance, backlog, and other case information

Importance of LIMS attributes for…

Small-Sized Laboratories

Daughter evidence	11.04
Chain of Custody Transfer	8.50
Management and Analyst Report Preparation	7.83
Pre-logging	6.74
System Command Navigation	6.40
Case Grouping	6.33
Query Access to Management Data	5.93
Generation of Analyst Summary Statistics	5.84
Case Prioritization	5.66
Court system status	5.65
Data Entry	5.35
Screen Manipulation	4.56
Terminal Mobility	4.03
Analyst Assignment	3.87
Case Evidence Status	3.79
Interface with analytical equipment	3.66
Personnel Certification Management	2.60
Asset Management	2.22

Preferred LIMS configuration for:l

Small-Sized Laboratories

- Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case.
- When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes.
- The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.
- The LIMS supports Pre-Logging by integrating with Agency Evidence Management Systems for initial data input.
- Supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation.

Importance of LIMS attributes for…	Preferred LIMS configuration for:l

Medium-Sized Laboratories

Management and Analyst Report Preparation	8.54
Daughter evidence	7.86
Chain of Custody Transfer	7.60
System Command Navigation	6.36
Generation of Analyst Summary Statistics	6.05
Case Prioritization	5.88
Data Entry	5.84
Screen Manipulation	5.82
Case Evidence Status	5.49
Pre-logging	5.36
Case Grouping	5.15
Interface with analytical equipment	5.05
Court system status	4.76
Query Access to Management Data	4.72
Terminal Mobility	4.29
Asset Management	3.93
Analyst Assignment	3.70
Personnel Certification Management	3.61

Medium-Sized Laboratories

- The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.
- Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case.
- When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes.
- Supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation.
- The LIMS allows analysts to create or access Summary Statistics showing performance, backlog, and other case information.

Importance of LIMS attributes for…	Preferred LIMS configuration for:l

Large-Sized Laboratories

Daughter evidence	9.09
Chain of Custody Transfer	8.38
Management and Analyst Report Preparation	8.21
Pre-logging	6.84
System Command Navigation	6.80
Data Entry	6.70
Generation of Analyst Summary Statistics	6.62
Court system status	5.44
Case Evidence Status	5.41
Analyst Assignment	4.97
Case Prioritization	4.80
Screen Manipulation	4.48
Case Grouping	4.20
Query Access to Management Data	4.15
Terminal Mobility	3.94
Interface with analytical equipment	3.85
Personnel Certification Management	3.08
Asset Management	3.03

Large-Sized Laboratories

- Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case.
- When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes.
- The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.
- The LIMS supports Pre-Logging by integrating with Agency Evidence Management Systems for initial data input.
- Supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation.

Importance of LIMS attributes for…		Preferred LIMS configuration for:l
Evidence Technicians		**Evidence Technicians**
Daughter evidence	9.24	• Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case.
Chain of Custody Transfer	7.88	• When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes.
Management and Analyst Report Preparation	7.20	• The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.
Pre-logging	6.95	• The LIMS supports Pre-Logging by integrating with Agency Evidence Management Systems for initial data input.
Data Entry	6.59	• The LIMS provides a high level of Data Entry automation.
System Command Navigation	6.45	
Case Grouping	6.19	
Generation of Analyst Summary Statistics	6.11	
Query Access to Management Data	5.79	
Screen Manipulation	5.66	
Case Prioritization	4.83	
Analyst Assignment	4.31	
Court system status	4.12	
Interface with analytical equipment	4.11	
Asset Management	3.92	
Terminal Mobility	3.82	
Case Evidence Status	3.80	
Personnel Certification Management	3.05	

Importance of LIMS attributes for…		Preferred LIMS configuration for:l
Scientists		**Scientists**
Management and Analyst Report Preparation	9.13	• The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.
Daughter evidence	8.95	• Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case.
Chain of Custody Transfer	7.80	• When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes.
System Command Navigation	6.93	• Supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation.
Pre-logging	6.55	• The LIMS supports Pre-Logging by integrating with Agency Evidence Management Systems for initial data input.
Generation of Analyst Summary Statistics	6.13	
Data Entry	5.96	
Case Prioritization	5.91	
Court system status	5.45	
Case Evidence Status	5.25	
Screen Manipulation	4.82	
Case Grouping	4.65	
Query Access to Management Data	4.49	
Interface with analytical equipment	4.48	
Terminal Mobility	4.11	
Analyst Assignment	3.91	
Asset Management	2.86	
Personnel Certification Management	2.64	

Importance of LIMS attributes for…		Preferred LIMS configuration for:l
Management		**Management**
Chain of Custody Transfer	8.44	• When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes. • Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case. • The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.
Daughter evidence	8.01	
Management and Analyst Report Preparation	7.43	
Generation of Analyst Summary Statistics	6.56	
Case Evidence Status	6.45	
Screen Manipulation	5.78	
Court system status	5.52	
Data Entry	5.48	
Case Prioritization	5.20	
System Command Navigation	4.96	
Personnel Certification Management	4.93	
Interface with analytical equipment	4.89	
Case Grouping	4.81	
Analyst Assignment	4.70	
Terminal Mobility	4.65	
Query Access to Management Data	4.21	
Asset Management	4.08	
Pre-logging	3.87	

Importance of LIMS attributes for…		Preferred LIMS configuration for:l
Laboratories with In-House Systems		**Laboratories with In-House Systems**
Daughter evidence	9.81	• Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case. • The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion. • When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes. • The LIMS supports Pre-Logging by integrating with Agency Evidence Management Systems for initial data input. • The LIMS provides a high level of Data Entry automation.
Management and Analyst Report Preparation	8.32	
Chain of Custody Transfer	7.92	
Pre-logging	6.63	
Data Entry	6.50	
System Command Navigation	6.37	
Generation of Analyst Summary Statistics	6.35	
Court system status	5.52	
Case Prioritization	5.19	
Case Grouping	5.00	
Query Access to Management Data	4.73	
Screen Manipulation	4.70	
Case Evidence Status	4.68	
Analyst Assignment	4.32	
Interface with analytical equipment	4.27	
Terminal Mobility	4.09	
Asset Management	2.93	
Personnel Certification Management	2.66	

Importance of LIMS attributes for…		Preferred LIMS configuration for:l
Laboratories with Commercial Systems		**Laboratories with Commercial Systems**
Management and Analyst Report Preparation	8.74	• When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes. • Supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation. • Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case. • The LIMS allows analysts to create or access Summary Statistics showing performance, backlog, and other case information. • The LIMS supports Case Prioritization using several criteria.
Daughter evidence	8.07	
Chain of Custody Transfer	7.87	
System Command Navigation	6.55	
Screen Manipulation	5.98	
Data Entry	5.94	
Generation of Analyst Summary Statistics	5.90	
Case Prioritization	5.68	
Case Evidence Status	5.67	
Pre-logging	5.53	
Case Grouping	5.17	
Query Access to Management Data	4.79	
Court system status	4.62	
Interface with analytical equipment	4.52	
Terminal Mobility	4.02	
Asset Management	3.79	
Analyst Assignment	3.61	
Personnel Certification Management	3.56	

INTRODUCTION

Forensics laboratories are charged with the examination of evidentiary material and reporting findings to a requesting agency. Given this, there exists a significant investment in time, personnel, instrumentation, accreditation, and domain knowledge within forensic laboratories. However, as demand for the analytic services provided through these laboratories has increased, the evolution of evidence management infrastructure has also had to undergo a corresponding geometric advancement. Laboratories, for example, once physically attached information about the evidence to the evidence itself with a string and a tag, and a worksheet which contained analysis results, analyst notes, and any other pertinent information that described the piece of evidence. This system of physical attachments and corresponding files (e.g. tags and manilla folders), coupled with low volume and small laboratory size made the management chain of custody and evidence analysis simple. In more recent years, however, forensic laboratories have seen increased demand for their services, as well as technology-driven differentiation of analyses offered – a piece of evidence today might need to go through several different areas of one forensics laboratory to receive the specialized attention that is required. Now, for example, a blood-stained shirt which had a suspected bullet hole could end up being examined for DNA, latent prints, trace amounts of drugs and/or toxicological substances, foreign fibers, and gunpowder residue – and at each examination point, there exists a need to maintain chain of custody and also preserve analyst findings.

The *need* for advancement beyond record keeping via the tag-and-worksheet approach presented earlier is obvious, given the above example, but what is not so immediately obvious is how to actually specify and build a system to meet this need in a manner which will provide for productive integration within the laboratory's operations, both current and future. Traditionally, laboratory information management systems (LIMS) have been viewed as an analyst-side tool, which took the place of a physical notebook. However, with the increase in both evidence volume and legal scrutiny (and potential refutation) of the results comes added scope, yielding LIMS implementations which tend to either under-perform or become unwieldy and cumbersome in their attempt to be everything for everybody. Modern forensics laboratories, then, need LIMS implementations that allow the lab to track evidentiary items through their examination lifecycle, and conduct analyses in a manner that is both efficient and thorough. Additionally, a modern LIMS implementation should also provide all levels of the organization a truly *useful* toolset above and beyond just evidence tracking.

Bearing the above constructs in mind, it is difficult to successfully grow a LIMS that can truly be everything to every individual in the laboratory. Hence, it is reasonable to expect that there is some natural tension and trade-off between features in LIMS implementations. Traditionally, the unwelcome task of weighing and substantiating these trade-offs between each other to synthesize a desired and idealized LIMS solution has fallen to either LIMS vendors or only to top-tier-management within the laboratory. This approach yields a LIMS implementation which runs the risk of not fully serving the laboratory staff, or the needs of their

stakeholders. A primary goal of this whitepaper, then, is to develop a decision support tool for forensics laboratories that can be used to compare and evaluate the capabilities and limitations of competing LIMS products. Thus, forensic laboratories can make use of this whitepaper as they see fit to systematically enhance their decision-making capability regarding LIMS acquisition. We provide a description of existing LIMS technologies, a comprehensive list of vendors that includes detailed descriptions of their product capabilities, a summary of the results from our data collection activities (including both focus group and survey information), an ordered set of criteria to be considered in evaluating LIMS systems, and finally, our recommendations as to how forensic laboratories can use these data to evaluate and select LIMS products more efficiently and parsimoniously.

This whitepaper is the culmination of a process, and throughout this process, we have conducted on-site interviews and focus groups to gather structured data about core requirements for LIMS systems in forensics laboratories. We then evaluated and summarized this data with the end goal of incorporating these data into our instrument – conjoint analysis. The data from the conjoint analysis has yielded insight into the characteristics of optimal LIMS systems, *as seen by forensic laboratory personnel at differing levels within the laboratories studied*.

OVERVIEW OF LABORATORY INFORMATION MANAGEMENT SYSTEMS

A LIMS is a complex information system that with varying purposes depending upon the users' specification at their respective installations. In the following section, we review the basic and advanced features that characterize forensic LIMS.

Log-In Functions

A key aspect of any LIMS is ability to capture and store key information about evidence materials at the initial login point. This process is crucial to the chain of custody and provenance of the evidence within the laboratory processes. The LIMS must provide for the input of operational data; origin of the material, analytical processes, and required reporting; demographic data; biological data about the victim(s) and suspect(s); and any billing data; what agency or jurisdiction which might need to be billed for the analysis.

Operational Data

At the initial login point it is important that the system include information on which analytical processes will performed on the evidence. It is also important that the system document what agency or entity is to receive the results of any analysis. A good LIMS will also provide for the input of any completion deadlines (i.e., trial dates or other statute dates) necessary for dissemination of the analysis results.

Evidentiary Data

The LIMS should provide for input of data related to the specifics of the evidence. The submitting agency or entity, the case number, jurisdiction identification, and in the case of DNA samples information regarding the health and physical characteristics of the suspect(s) and victim(s). This information should be controlled so as not to bias the analytical process, but certain biological information about the suspect(s) and victim(s) may be necessary to fully complete the analysis.

Billing Data

Obviously many forensic laboratories do not charge back jurisdictions for their services, but as the popularity of outsourcing many laboratory analyses grows there is a growing need for laboratories to provide clients with detailed invoices for their laboratory services. A good LIMS will provide for this functionality. Thus, the system needs to capture pertinent billing data during the initial login function.

Evidence Tracking

Evidence tracking is the baseline function for any LIMS. Users depend upon the LIMS to locate evidence within the laboratory, report on the status of the scientific analysis, provide a log of all custodial changes, and report on the final disposition of the evidence material. The system should be able to list evidence, identify its location, and identify any actions (sample preparation, analysis, interpretation, etc.) that need to be completed. The ability for the LIMS

to retrieve evidentiary information is imperative, as it is necessary to recall evidence waiting for analysis, evidence in analysis, and evidence in which analysis has been completed. Most LIMS provide standardized reports which are generated periodically to monitor production, backlog, work lists, turn around time analysis, etc.

Evidence tracking should provide the user with a status report on the evidence, and this report should include where the evidence material is located in the laboratory (which section), how long it has been in each section, which analysts handled the evidence, and which scientific processes are yet to be completed.

Bar Coding and Evidence Tracking

One of the best ways of streamlining the laboratory inventory management process is through the use of bar codes. This technology allows the laboratories to increase the amount of data available on a sample label by storing both text and numeric values. The bar code system allows the data to be input into the LIMS while minimizing the need for entry duplication. Bar coding allows for accessing and tracking evidence more rapidly and smoothly than manual systems.

Bar coding is a standard in business applications and studies of other inventorying processes indicate that bar coding is typically 20 times faster and more than 20,000 times more accurate than manual keyboard entry. Bar codes are fairly easy to implement, as hardware and software applications are available for only a nominal investment. A basic system consists of a scanner (typically

handheld), a decoder, a computer barcode font, and a printer. Some laboratories prefer to use pre-printed barcodes which is also fine. The scanner reads the bar code by emitting a light from a diode. The light is reflected back onto a photodetector, creating a signal that is sent to the decoder. The decoder converts the signal to a computer character set and this information is passed to a computer application.

Other bar code scanning devices are becoming popular. Typical of these new devices are optical character recognition (OCR) scanners. OCR scanners can be used to input recognizable characters which allow technicians and the computer to use the same labels. These are good devices, but the technology is not yet as robust or reliable as bar code scanners.

Support for Analyst Functions

Analysis Request

The process of evidence analysis begins with the submission of evidentiary material and a specified request for analysis by authorized personnel from the responsible jurisdiction. Ideally the specific request should be recorded when the material is initially logged into the forensic laboratory.

Evidence Collection and Submission

When evidentiary material is submitted, it must be logged into the laboratory either manually or electronically via the LIMS. Personnel also need the ability to log the condition of the sample evidence.

Evidence Login

The system must assign a unique identification number to each piece of evidence at the time the material is logged in. The requested analyses should also be logged in at this time.

Distribution of Samples

The system should assist the laboratory personnel (specifically the section directors and analysts) with work lists, routing instructions, analysis scheduling, labeling, and chain of custody logging.

Schedule of Analysis

The system should have the capability to schedule analyses based upon work load and resource data. The system should draw upon reagent inventories, previous scheduled analyses, court dates, and priority codes to assist managers with laboratory scheduling.

Analysis

During the analysis the system should provide measurement and result capture, documentation of analysis preparation procedures, test measurements, calibrations, and quality control processes.

Sample Preparation

In some cases evidentiary material needs preparation steps that must be documented in order to accurately perform a scientific analysis. The system should have the ability to log the preparation procedures.

Sample Measurement

The actual results of any analysis are the focus of, and purpose for, the forensic laboratories' existence. The actual measurement process may include results that are manually input or those that are electronically input from an integrated instrument. Additionally, any self-checks, blanks, or calibrations should be captured as part of each result reporting.

Verification and Correction

Most scientific analyses in a forensic laboratory will typically require the verification of the results from another expert in the discipline. The system must be able to capture and record the identification of the verifier, along with his or her credentials. Abnormal results or results that are outside of acceptable ranges should be flagged for further scrutiny. Any corrections entered should be done during this step and the system should provide functionality that will only allow authorized personnel to make changes. Finally, the system must generate an audit trail of any alterations made.

Reporting

Once the results have been verified the system must have the capability to generate reports of the analyses to the appropriate agencies and jurisdictions involved. The reporting apparatus should be flexible enough to customize the reporting process for different reporting entities and a variety of requirements.

Lab data sheets. The bench analysts use laboratory data sheets to record and document their analytical procedures. These sheets are completed

concurrent with the scientific procedure performed. Data sheets are part of the raw data and must be kept as part of the documentation of laboratory process. The data sheets are used as input documents for entry of results data into the laboratory information management system. Some systems provide for the scanning of lab data sheets so that this data can be stored electronically and integrated with the other stored computer data.

Log books. Laboratory log books contain information about initial login, analysis requests, calculations, test results, sample status and location, calibrations, and chain of custody data. Like lab data sheets this information could be captured and stored electronically, but the manual forms must still be archived.

Interpretation

The final conclusions drawn by the analysts from the test procedures are part of the final report and the system should provide analysts the ability to provide their conclusions from the scientific analysis.

Disposal of Sample Materials

Once the analysis has been completed the system needs to record the disposition of all tested and manipulated evidence. The system must indicate the location of any remaining material and state the disposition of any material consumed or discarded as part of the analytical process.

Biometric Identification

For many laboratory functions biometric identification is not only possible but preferable. The main advantage of biometric identification systems is the enhanced security that the systems provide. If the level of security required by the forensic laboratory is significant, biometric identification of laboratory personnel should be considered. Table 1 identifies the various types of biometric identification techniques available.

Table 1 - Types of Biometric Identification Systems

Technique	Analysis Procedure
Retina Scanning	Most accurate biometric technique. Examines the layer of blood vessels located at the back of the eye (retina) for pattern recognition.
Iris Recognition	Analyzes the pattern of the colored ring that surrounds the pupil of the eye (iris).
Finger Scanning	Fingerprint or thumbprint. Analysis of the images of the ridge endings, bifurcations, and branches made by the ridges.
Finger Geometry	A three-dimensional image of the finger captured by a camera.
Palm Scanning	Examination of palm minutiae (similar to fingerprint examination).
Hand Geometry	A three-dimensional image of the palm (similar to finger geometry analysis).
Voice Recognition	Examination of the unique characteristics of the voice based on both physical (e.g. timbre and pitch) and behavioral (e.g. rhythm) characteristics.
Face Recognition	Examination of either a visible-light or infrared image. Analyzes the shape, pattern and positioning of facial features.
Signature Analysis	Examination of the unique characteristics of the signature. Analysis of individual characteristics such as letter formation, pen movement, angle of pen, and pressure applications.

Results from Scientific Analysis

Results from scientific analysis must be input into the LIMS. This can be accomplished via manual results input or through an automated method. All systems allow for results to be entered manually into the system by the analysts, but results can also be entered into the system electronically if the scientific instrument is integrated with the LIMS. Even when instruments are integrated

with the LIMS, the analyst must review the "uploaded" data to ensure its accuracy.

Review of Scientific Analysis Results

Data entered into the LIMS must be both accurate and valid. Verifying the results of laboratory analysis takes several steps. First, the analysts must set acceptable and appropriate limits for the test results. Typically these are split into absolute limits that must not be exceeded and warning limits that indicate the results are outside normal boundaries. Once the limits are established for each scientific process the LIMS will automatically warn the analysts of results outside standard boundaries. These results are typically flagged by the system, thus prompting analysts to critically review those results.

Audit Trails

Once the results have been verified and approved, the LIMS should provide functionality to prevent the alteration of results *a posteriori*. If subsequent analysis indicates the results require changes, the system should create an audit trail that specifically indicates the altered data, the person making the alteration, the individual approving this alteration, and the reason for the change. This is essential to any LIMS for forensic laboratories since this goes to the heart of evidentiary provenance and the admissibility of the results of scientific analysis in a court of law.

Reporting the Results

The LIMS should generate result reports on both an individual test, case, and by agency or jurisdiction. The system should have the ability to produce a report for any single scientific analysis. Additionally, the system should be able to aggregate the reporting for all evidence analysis conducted on a variety of materials for any specific case. And finally, the system should have the ability to aggregate analyses conducted for any specific client agency or jurisdiction within a specified time-frame. This reporting is crucial not only for the verification of individual case evidence, but it is also key to providing summary data for laboratory management.

ADVANCED FEATURES OF LIMS

Evidence Analysis Scheduling

In many generic LIMS systems, functionality is provided to allow for routinely scheduled sample testing to be input into the system. Evidence analysis in forensic laboratories has activities which are both limited and routine. However, there is a strong likelihood that there is a steady stream of drug or assault evidence analysis that occurs on a fairly routine basis. In commercial laboratory systems these routine cases enter the system through a pre-logging process. The sample is routinely scheduled as “pending” and its actual status is updated to “logged” once the samples are received. Most forensic laboratory software, however, does not provide this type of pre-logging functionality.

Instrumentation Validation & Integration

One of the beneficial features of laboratory information management systems is their ability to integrate laboratory instrument measurement and computations into the information processing capabilities of the laboratory information management system. These files replace the keyboard input and provide electronic input directly from the analytic instruments.

Instrument manufacturers have recently made enhancements to their products allowing for significant integration with laboratory information management systems. Typically instrument manufacturers have provided one of three types of integration; automatic input of instrument output file data, proprietary software output which requires special programming to facilitate system integration, and standardized and/or generic output which can be easily integrated into any other software application.

Most modern instrument systems provide common output formats. Comma separated values, (CSV) files are a standard output format, and can be read by Microsoft software applications like Microsoft Access and Microsoft Excel. The actual integration can be accomplished in a number of ways. The data may be downloaded from the instrument and imported into the laboratory information management system. This usually requires a data format conversion, hence the need to “import” the data. In some cases the data is encrypted in the analytic instrument measurement process and then decrypted by the laboratory information management system software as it is input into the system. Once the data is present within the laboratory information management

system, it will be subjected to all of the other validation and quality assurance processes as any other data within the LIMS.

Enhanced Data Quality

These integration capabilities help enhance the quality of the data input. With system interface automation comes a reduction in data contamination due to human error. In addition to the automated integration of scientific laboratory instruments advanced database capabilities also improve the quality of laboratory management data.

Data Entry Restrictions

One of the best ways to ensure that the laboratory maintains accurate data is through the data entry restrictions which can be established within the database. Any program or application attempting to insert or update data in the database must comply with these data entry restrictions in order to be accepted into the database. The entry restrictions are set up by the database administrator using database “triggers” which initiate the restriction validation routines whenever programs attempt to insert or update any data items. For example, the entry restrictions might be set up to allow data entries within a valid range or within appropriate limits, say ballistic speeds no smaller than zero feet per second, blood rH either positive or negative, or valid sequences of firearm serial numbers. These restrictions which allow only valid and/or appropriate data to be entered initially are some of the best tools available in data management to ensure the integrity of the data and evidence within the laboratory.

Double Data Entry Screens

In most clinical settings, data is entered into the system using two separate input screens. The data can either be input by one person or many people, but this feature is an added validation check to ensure the accuracy of measurement readings and data entry from the initial system input.

Range and Limit Checking

This is a special case of the data entry restrictions feature. This feature allows the system to accept data entries within a set range. Entries made outside the established range limits will automatically alert the user to the possibility of a data entry error. The user then will have the option to validate and, if needed, correct the data.

Limit to List

To assist in data entry and improve the accuracy of data input, the system will provide a limited list of valid options from which the user may choose. These lists are usually presented to the user in the form of a 'drop down' list box which allows the user to select from a list of valid choices. Often these input facilities also allow the user to input data by typing in the first few characters of a data item and the system will provide commonly used inputs as options to choose from. Both these techniques are not only more efficient for the user, but help eliminate typographical and spelling errors.

Automatic Calculations

Once data is entered into the system succeeding calculations can be created automatically by the system. Durations, sample consumption, and analysis progress can be tracked easily by the system. Laboratory efficiency reports can be produced in aggregate, or by department or analyst, formats to assist laboratory directors with the management of the laboratory processes.

Automatic Reporting

This feature allows the system to be set up to automatically generate reports and forward the data to the correct recipients. Results can be automatically routed via e-mail or fax to analysts and affiliated agencies. This, along with automatic laboratory management reports, can help reduce the backlog of the laboratory and improve response time to the recipients.

Reduced Turnaround Time

All of the techniques addressed above facilitate increased throughput of the laboratory information management system. The bench analysts are required to spend less time dealing with mundane paperwork, while the data entry process is streamlined and clerical data entry errors are significantly reduced.

Supply Inventory Management

Most LIMS have expanded their functionality to incorporate features that provide for the management of chemicals, reagents, and supply inventories. Typically the systems will allow the individual laboratories to specify the amount

of chemicals and reagents used in each scientific test. The LIMS then automatically calculates inventory levels based upon initial inventory amounts and the activities recorded in the laboratory. Most systems provide laboratory users with warning reports when inventories drop below specified safety stock ranges. The systems typically allow for the recording of vendor and order information, as well as quantity, grade, cost, shelf-life, shipping and handling information, and safety sheet information. Some systems even provide the ability to link to vendor web sites.

Some of the most sophisticated systems will create proforma reports which anticipate when inventories will need replacement stock based upon scheduled analyses within the system. In all cases the system reports are only valid if care and consideration is given to the data input initially as well as the consumption amounts. Laboratory personnel should be vigilant to monitor this process manually until the system proves accurate.

Human Resource Management

A key aspect of state-of-the-art laboratory information management systems is their ability to assist in the management of records on laboratory personnel. The LIMS provides functionality to allow input of personnel credentials, the status of training programs, and the currency of certifications. The system can function as a “tickler” file reminding both bench analysts and section managers of impending certification updates and required training programs. Typically, the laboratory director and section managers have the ability to input certification requirements and scheduled training programs

necessary to conduct specific scientific testing. If an employee's credentials have expired, the system will not allow the employee to be scheduled to conduct the analysis and any results from any such testing will not be validated by the system.

Similarly, current LIMS have the ability to track the maintenance records and status of scientific equipment. Periodic equipment calibrations, repairs, and routine maintenance schedules are monitored by the system, and scheduled updates may be planned through the LIMS. As with personnel, warnings and advisory messages are automatically sent to laboratory management personnel to better facilitate the management of laboratory instruments.

Data Archiving

Archiving data is crucial not only to the provenance of the evidence but to the efficient functioning of the laboratory. The nature of the forensic laboratory requires that data be maintained for an extremely long period of time, if not permanently. However, it is important for optimal operation that older data be archived to allow more efficient processing of current data. Archiving data allows the laboratory to significantly enhance system performance by cleaning up the database while simultaneously aiding data pertinence by removing outdated testing and analysis methods. Finally, archiving is necessary simply to remove data which has reached the limits of its statutory requirements.

Data Warehousing

Management reports are often generated from the information stored in the system's database. However, this activity can be detrimental to the performance of the database in the production environment. To avoid downtime in the laboratory activities, data can be copied and stored within a data warehouse where analysis reports can be generated without degrading the performance of the production system. Data warehousing offers the advantages of enabling relatively easy access to data, providing a way to look at data historically (data warehouses archive data, which allows analyses to incorporate historical data), and creating a resource that is focused on supporting decision making. A data warehouse will require more data storage, since data will be duplicated in whole or in part in another location, but it is generally viewed as an asset because it increases the value of data by enabling users to examine data in new and innovative ways.

Backup Management

Laboratory managers must establish good backup procedures to minimize the impact of data loss or database corruption. The appropriate backup strategy will consider the effort to recreate the data that might be lost. Consideration must be given to the amount of time, effort, and resources required to collect and enter the data initially. As the amount of these factors increases, the sophistication and resources expended on the backup procedure will rise proportionately.

Commercial software applications are available to assist laboratory managers with the backup process. There are also a wide variety of storage

media available for backup management. It is important to realize that, as parallel computing power grows, the capacity of storage media options increases geometrically (Laudon, 1998) with a doubling about every two years. So it is important to review the media use and the amount of data backed up periodically. Currently, read-writable CD-ROMs and DVD-ROMs are popular storage options due to their relative low cost, high capacity, durability, and ease of storage and use.

Scheduling:

When a laboratory creates a backup procedure there are several strategies available. The major types of options are full, incremental (also known as delta), and differential (Bishop, 2004). A full backup archives *all* data whether it has been previously backed up or not. Incremental only performs an archival of files that have been created or modified since the prior backup procedure was run. Incremental strategies must always be done in conjunction with a full backup in order to establish a baseline from which the incremental data can work. This is the fastest approach, but can be problematic during the restore process, as an incremental backup will require use of the full backup and then the sequential restoration of all subsequent incremental backups that make up the archive set.

A differential backup process is similar to the incremental approach, however the archival is not eliminated. The advantage of the differential approach is that only two data restorations are required: the full baseline backup and the single incremental backup which contains all subsequent modifications.

Testing Backup Procedures. Any backup procedure created must be tested to ensure that the result is as anticipated. The best way to test the procedure is to test it on a *non-production*, stand-alone system. The entire sequence of backups must be tested in order to ensure the accuracy of the procedure. Any part of the incremental backup procedure that is not tested has the potential to create a complete failure of the entire backup procedure.

Off-site storage. An often overlooked aspect of any backup procedure is the incorporation of an off-site storage location. It is absolutely essential to store the backup media in a location separate from the computer system. Commercial vendors (e.g. Connected, GoDaddy, @Backup, NovaStor) are usually available in every location which can provide a turn-key solution for off-site storage for your laboratory.

OVERVIEW OF LIMS DEVELOPMENT

The development process for creating a new information system is typically done in a very systematic and prescribed fashion.

Standard Systems Development Life Cycle

Most large organizations today use some version of the standard Systems Development Life Cycle (SDLC) approach to developing new information systems. The approach is very linear and methodical. SDLC is a logical process designed to assist system engineers, software analysts, programmers, and project managers with a systematic way to plan, implement, maintain, and control software development projects (Enger, 1982). The typical phases of SDLC are

shown in Figure 1. These phases include systems investigation, systems analysis, systems design, implementation (which includes programming, testing, and data conversion), and system maintenance. Some information systems professionals use slightly different vernacular and segment the phases differently, but these are the basic categories of activities and tasks.

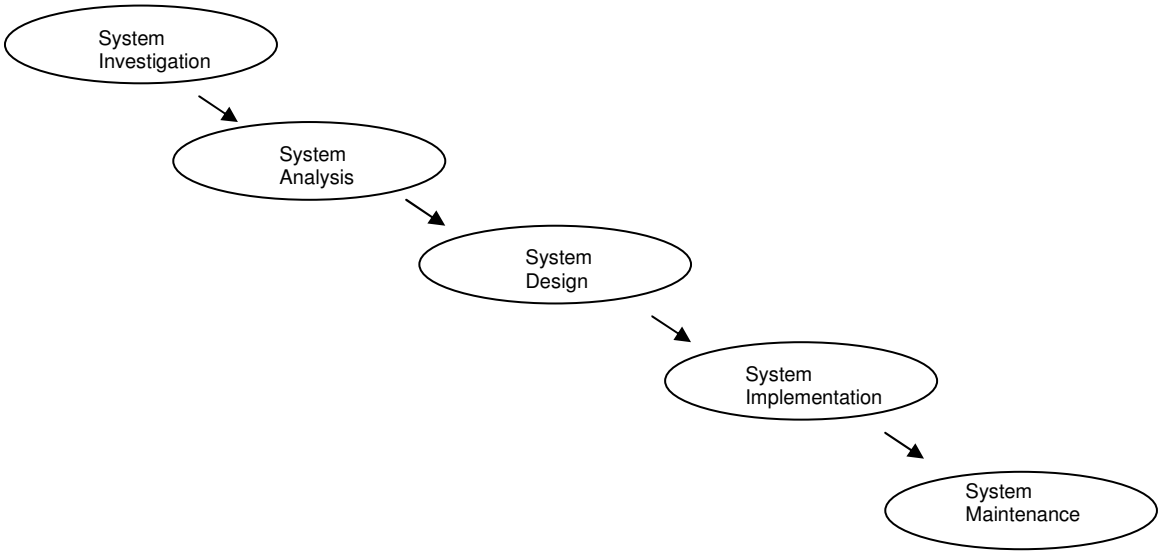


Figure 1 – Typical SDLC Phases

System Definition

The initial task in the Systems Investigation phase is to define the system problem and its boundaries. This is a very important initial task since this definition sets the scope of the system project. For example, the system problem could be defined as a very general laboratory information management system which would incorporate all aspects of laboratory management or it could be focused very specifically on some specific laboratory function such as evidence inventory management or chain of custody. The system definition and problem

identification will drive the pervasiveness of the proposed solutions. This step will determine overall scope of the project. Failure to reach consensus on this definition early in the project could lead to communication errors, development mistakes, and management debates in the phases of the SDLC process. Ultimately a poor definition could lead to an unsuccessful system implementation.

Feasibility Analysis

Early in the process of acquiring a new system an initial analysis of the system's feasibility should be undertaken. Feasibility analysis begins at this early point in the process, but is not concluded until the end of the conversion process. This process is somewhat unique since it runs concurrently with the other iterative steps in the development life cycle. The feasibility of any system is constantly monitored throughout the development or acquisition process. This concurrency is necessary since technical considerations, business function requirements, or economic changes may precipitate the need to abandon an ongoing process if a significant change no longer makes the new system a viable solution.

There are several different types of issues that the feasibility analysis must address. Traditionally, we think about feasible solutions as simply a financial budgeting process to ensure that the system is affordable. However, there are a number of other issues that could make the proposed system infeasible.

Technical Feasibility. Technical feasibility considers the technical aspects of the proposed system. This assessment focuses on the practicality of the proposed solution from a technical point of view. The analysis should consider

the hardware, software, and networking requirements to operationalize the system. Laboratory management systems are application software and will have specific hardware and operating system requirements. Without a supported operating system, a LIMS will be unable to run on the organization's hardware platform. A particular platform and operating system requirement could eliminate a specific application from consideration if the incapability can not be resolved. Even more typical is the requirement of a software application to work with a specific database program. Application software typically relies on a specific database platform to store and retrieve the application data. Simply purchasing or building the software application is not sufficient. The organization may need to acquire a database management system to support the laboratory management application. This can limit software options through mandating a specific database vendor. The organization may be faced with the option of acquiring (and maintaining) a different database system just to support a particular laboratory information management system.

Additionally, we must consider not only the technology but the personnel. Does the organization possess personnel who have the technical skill sets to develop and operate the proposed system? If not, then the organization must assess their ability to acquire these skills either through training or acquisition of trained personnel.

Operational Feasibility. Operational feasibility focuses on the appropriateness of the solution for the problem. The first question asks if the problem is worth solving. Some problems are only temporal and by the time a

sophisticated solution is developed changes in operational context may have rendered the problem inconsequential. Once the laboratory is confident that the problem is worth solving, the organization must assess the urgency of the problem and measure the feelings and thoughts of the end-users and organization management toward the proposed solution.

There are many aspects to the proposed solution that need to be addressed in terms of their ability to address the problem. These would include the following questions:

Is the proposed solution going to provide adequate throughput and performance?

Will the solution provide adequate capacity to meets the functional needs of the organization?

Does the solution have adequate controls to ensure the system is working properly?

Is the data provided by the system adequate in terms of accuracy, timeliness, formatting, and relevance?

Does the organization have adequate resources to operationalize the system?

Finally, the system must be assessed in terms of its cultural fit with the organization. Not all laboratories are managed alike. Some are highly centralized, while others operate each section more independently. If the developed solution provides a heavily centralized decision-making focus, but the organization is very decentralized, the proposed solution will undoubtedly be met

with resistance from users and managers alike. Managers and users must feel comfortable with the role they play in any proposed solution. In order for users and managers to support the development and implementation of a new system, it must be user-friendly, easy to learn and use, and add value to the organization.

Legal Feasibility. Many times potential solutions to business problems are identified which can correct a business problem. The solutions may meet all of the feasibility requirements, but the proposed solution may not be *legally* viable. For example, a laboratory which must share data with an affiliated laboratory might design a system that sends data over the Internet. Due to bandwidth limitations the lab might design a system that doesn't encrypt or otherwise secure the data during transmission. While this system may well meet the other feasibility requirements, it would potentially expose the laboratory to litigation for failing to exercise due diligence to ensure that the data is not intercepted during transmission. Therefore, the solution here, while technically feasible, becomes intractably infeasible from a legal standpoint.

Schedule Feasibility. Often organizations assess a multitude of issues concerning the feasibility of a new system. However, one aspect that is often given limited attention is schedule feasibility. Sometimes organizations assume that a project can always meet its conversion deadline, if only by adding more resources to the project to ensure its completion. This can be a very grave mistake. Given the estimation of timetables and resource allocation, projects have inherent uncertainty; therefore, proposed schedules tied to these projects

are often inaccurate. Adequate contingency planning for schedule overruns needs to be incorporated into any new system implementation project.

Many times the initial systems investigation phase does not begin until some crisis occurs. Then an inordinate amount of time is spent analyzing the problem and discussing alternative solutions. This process will often leave a very tight window of time for the system to be implemented. The most widely known schedule feasibility event occurred for most organizations very recently, when organizations scrambled to prepare for the Y2K rollover. Many organizations identified the problem, but spent so much time considering the alternatives that once a decision was finalized the system developers were left with very tight schedules in order to meet the hard deadline of January 1, 2000.

Functional Requirements

In the Systems Analysis phase the goal is to understand the current process requirements in order to design a feasible and appropriate system solution. The analysis is typically done in two steps. The first step focuses on the functional aspects of the work unit processes and the second step examines the technical aspects of the current processes. This first step in analyzing a new system is to determine what needs to be accomplished from a functional standpoint. This process includes an assessment of the functional activities done within the work unit so that the system can be designed to meet the functional demands of the work unit. The analysts must examine the current processes to understand the functions that need to be accomplished. The focus must remain on “what” is to be done and not “how” it is currently done.

Reporting Requirements

One of the best ways to determine the "what" of a process is to examine the reporting requirements. *Who* needs to receive *what* data? The "who" is not a specific individual such as "Sam Jones", but a given role within the laboratory, such as "Firearms Section Supervisor". By focusing on the information that needs to be provided, the system developers can determine the output requirements for each functional process.

Data Capture Requirements

The corollary to the reporting requirements analysis is the data capture requirements. Once the output of a functional process has been determined, the analyst will analyze the process to determine what data must be captured in order to fulfill the reporting requirements. The analyst will continue to be concerned with *what* data is acquired, and not *how* or *where* this acquisition takes place. Too much focus on the "where" and "how" will tend to limit the analyst's creativity during the system design phase. The best design will fully address the functional requirements and not put an inordinate emphasis on the technical design. It is important to focus on the reporting requirements first rather than the data capture requirements, otherwise the solution will tend to look for information to share which may have little or no informational value.

Technical Requirements

While the functional analysis needs to drive the analysis process there may be technical requirements that need to be considered. The analyst must

document the overall architecture of the existing information system. For example, any new solution will likely have to be integrated with the existing information technology infrastructure. This may require an analysis of the current operating system and/or database management system that the laboratory uses. There may be other technical considerations that must be documented at this point. Such considerations can include networking infrastructure and connectivity, system throughput and processor capacity, the number of available nodes within the network, wireless access capabilities, the volume of transactions handled by the system, system interface requirements, communication requirements, and data exchange requirements.

Functional Design

Once the system analysis is complete, the system developers will begin to focus on the design of a single solution, or solution set that will satisfy the functional requirements of the system. Congruent with the functional analysis, the focus here initially falls on the process and not the technical aspects of the system. The analyst will create a solution designed to meet the reporting requirements of the process. The solution will also provide information on where the data is created, updated, and deleted within the proposed solution.

Technical Design

The functional design will necessarily drive the technical design of the proposed solution. The technical design will focus less on the business issues and provide the software developers with specifications for the networking, data

sharing, and data manipulation requirements of the functional design in order to meet the business process needs of the users.

Implementation

Personnel Training

There are two types of personnel training; user training and computer personnel training. System developers and system operators must usually be trained prior to the data conversion and system creation stages. The developers may need to learn new database management systems, computer operating environments, or new software development languages.

Training of the development team and operational personnel is one of the most overlooked aspects of systems development, yet development team training may be one of the first technical requirements to get the project underway. New systems require users to learn new processes and procedures. It is impossible to successfully convert to a new system and expect users to intuitively understand how the new system operates. This is true even of users who work closely with the development team to create the system specifications. If adequate time and resources are not dedicated to the training of user personnel, the project will suffer morale problems, absenteeism, employee turnover, and outright system failure.

Data Conversion

Data conversion occurs when the existing system data is converted to run under the newly developed system. There are several approaches to

conversion. The most straightforward approach is the direct approach, which entails cutting off the old system and starting up the new system without any intermediate steps. This is also the most risky approach because any problems that are subsequently discovered will not be able to be corrected in an orderly fashion. The second approach is the pilot conversion, requiring the introduction of the new system to only a portion of the laboratory. For example, the system might only be implemented within the Latent Print section. Thus, system issues will have only a limited impact on the entire laboratory and corrections can be made with minimal disruption. The phased approach is very similar but requires the introduction of only a limited set of system functionality to the entire organization, thus mitigating the impact of any problems to only a few functions within the laboratory.

The most resource-intensive approach is the parallel approach. This involves operating two systems (the old and the new) simultaneously. While this might not be practical for all environments, this approach is the most robust and fail-safe. The advantage of this approach is that the new system can be directly compared to the old system data for verification. If any inconsistencies are discovered, the old system remains in place and the impact on the data is minimal.

System Creation

System creation represents the code development phase of development. In this phase the programmers create and unit test the code to ensure that it meets the design specifications outlined in the design documents by the

analysts. This may be done using traditional software languages, 4th generation code generators, or object-oriented programming techniques.

System Validation

Once the code has been unit tested at the unit or module level the blocks of code are linked with prior procedures and subsequent programming logic to test the accuracy of the functionality. This process is called string testing and can be very complex depending upon the amount of sophistication of the software. Testing will typically consume about 60% of the total implementation time. Every logic branch of software must be tested to ensure that all combinations of transactions and data are handled properly. Failure to dedicate adequate resources to the testing phase will undoubtedly cause geometrically greater losses of data and system integrity once in the production phase.

System Integration

In addition to the unit and string testing done in the validation stage, the software will be tested in a more comprehensive manner during the integration. This phase tests the accuracy and functioning of the system when it is coupled with other related systems. The ability of data to flow and be processed accurately between systems and subsystems is complex and requires adequate resource allocation.

System Evaluation and Maintenance

The final step of the development process is the evaluation and maintenance phase. The system remains in this phase until it is replaced by a

successor system. Periodically the system may have formal reviews to assess its functioning and fulfillment of users needs. More typically, the system functions without formal review and enhancements or modifications are made only when users make requests for required changes. As the system ages, the cost of maintenance tends to increase. The cost and availability of hardware increases, the software language used to create the system may become obsolete, and the basic computing infrastructure may experience an "end of life" condition in which support is no longer available. Typically a system is maintained until these issues make further maintenance and enhancements more costly than the creation and benefits of a new replacement system.

Vendor Selection

Whether an outside vendor is used to provide a turn-key solution or only to provide a hardware platform or software application, there are some common steps in the selection process.

Vendor Review

All potential vendors must be reviewed in terms of their products, their technical ability, and their business health. Any system component can be immediately rendered obsolete if the vendor's business fails, is purchased, or for any reason discontinues its support of the product. It is important to evaluate vendors not only for the soundness of their products but for their reliability and probability of the business remaining solvent. Each vendor should be evaluated, and a profile of each vendor should be generated.

Technical Issues

The laboratory must also evaluate the technical aspects of any candidate system. Systems can be too complex where processing capabilities are simply too ambitious to adequately place into production. Similarly, some systems may be too simplistic and not provide the technical sophistication required to fulfill the users' functional requirements.

Assessment of In-House Personnel Skills

In any evaluation of outside vendors, there is the inclination to discount the effort and technical skill required to produce the system under evaluation. One of the best ways to accurately assess the value of any candidate system is to evaluate the skills and capabilities of any in-house personnel resources. Often when systems are evaluated in light of the effort and resource commitment required for in-house personnel to create a comparable system, the value of the vendor products tend to increase.

Resource Availability

Even if a laboratory or jurisdiction has capable personnel to create a similar or even superior system, the practical availability of those resources must be assessed. A laboratory possessing skilled in-house personnel will typically have already committed these resources to other development projects.

Hardware & Software Considerations

It is always important to remember, when choosing an outside vendor, that no computer system product works in a vacuum. The type of hardware a

software application is designed to run on is imperative and not a trivial matter. More typically there are compatibility issues between database management systems and application software packages. Also, compatibility issues between database systems and hardware vendors also exist. A thorough evaluation of these factors must be done in the initial consideration phase of the project.

ADDITIONAL LIMS COMPETENCIES

Regulatory Issues

Laboratory competency is demonstrated via laboratory accreditation, which ensures that the laboratory performs tasks and processes consistent with accepted standards, although there are no standardized accreditation programs. Laboratories can be accredited to test in an entire field of science, in a specific discipline, with a specific product, or using a specific technology. Forensic laboratories utilize a wide variety of scientific methods to accomplish their objectives and thus are subject to a myriad of scientific accreditation programs. Additionally, the need to provide irrefutable evidence requires forensic laboratories to achieve the highest level of certification in nearly every section or department.

ISO 9000

ISO 9000 is a series of standards that defines quality (ISO 9000, 2005) set forth by the International Organization for Standardization (ISO). It focuses on what should be done and not how it is accomplished. Section 4 of the standard

sets forth 20 areas of quality conformance. This standard is primarily applicable to manufacturing laboratories and is not directly applicable to forensic laboratories. However, the quality aspects of what should be done are certainly aspirant standards.

ISO Guide 25

ISO Guide 25 (ISO 17025, 2005a; ISO 17025, 2005b) is specific to the goal of ensuring adequate test data. This is the most applicable standard for laboratories in general and thus is the most relevant to forensic laboratories. ISO Guide 25 is the most widely recognized standard for laboratory accreditation.

Good Automated Laboratory Practices (GALP)

GALP (EPA Manual 2185, 2005) are a collection of federal policies, regulations, and guidelines that establish a set of procedures that ensure the reliability and credibility of laboratory data. These practices were established by the Environmental Protection Agency (EPA) in response to problems found in laboratories with respect to modification, loss, and corruption of data by EPA contractors. These practices apply to all laboratories that interact with the EPA. The policies set standards for the collection, analysis, processing, and storage of data that is subject to EPA oversight. While forensic laboratories are not directly subject to EPA standards, the policies still provide useful guidance with respect to good laboratory management practices.

Electronic Signatures

In August of 1997 the Food and Drug Administration (FDA) created regulations that provide guidance and standards for the submission of test results and reports with electronic signatures. Many laboratory management software applications have functionality available that incorporates the standards set forth by the FDA. The acceptance of electronic signatures by analysts in verification of analysis procedures varies by jurisdiction, but is not yet widespread. Again, forensic laboratories do not fall under this jurisdiction but the standards may be helpful.

National Environmental Laboratory Accreditation Conference (NELAC)

NELAC is another EPA related standard. The NELAC is sponsored by the EPA in an effort to develop a generally-accepted set of laboratory data management standards for all laboratories processing test data.

Equipment. A good laboratory information management system will provide for the input and maintenance of records regarding major equipment used in the forensic laboratory. The system should track information such as the manufacturer, equipment name, equipment model, serial number, manufacture date, in-service date, maintenance reports, repair history, and dates and results of calibration. All measuring devices including, balances, thermometers, volumetric devices, controls, micrometers, etc., must be verified to ensure the accuracy of analysis procedures.

Calibration. An acceptable laboratory information management system should be able to track the reporting limit and method testing limits of each

instrument. The system should also provide a record of the initial calibration and of all subsequent calibrations.

Evidence Handling. The system must have a method for uniquely identifying each piece of evidence and for aggregating and disaggregating portions of any sample material. The system must have the ability to uniquely identify each piece of material when it is logged in. The system should also provide a text field allowing the logging technician to note the condition of each piece, should such a description be necessary. The system must be able to log and report the chain of custody, the current location of the evidence, and completed and remaining analyses.

Data Archiving. The laboratory information management system should be able to provide an historical report of the activities related to each analytical procedure performed on any piece of evidentiary material. This record should provide the identity of the personnel who not only had custody of the evidence, but of personnel that had proximate access to the evidence material. Additionally, the system should provide detailed reporting on analysis preparation, calibration of instrumentation, analysis procedures, reporting, and verification of analytical findings. Finally, the system should provide an audit trail regarding any changes to the reported results including an explanation of the nature and reason for the alterations.

Sample Tracking. The system should be able to pinpoint the location of the material in the laboratory inventory, i.e., which section, locker, shelf, container. The system should also be able to provide information regarding

identification, receipt, acceptance or rejection status, ID codes, segmentation history, aggregation history, analysis descriptions, dates of analysis, analysis personnel, data and statistical calculations, calibrations, quality controls, analyst signatures and initials, measurements, and storage details.

Laboratory Report Formatting. The system should be able to provide standardized report formatting which clearly communicates the status and history of the evidentiary material and its related analysis. Data should include the name and address of the laboratory, contact name and phone number, case number, unique identification of the report including total pages and report number, jurisdiction, agency, identification of analytical personnel, credentials of analytical personnel, requested analysis, dates of analysis, results, analytical methods, location of the evidence, and disposition of segmented portions of the material.

ANALYSIS OF COMMERCIALLY-AVAILABLE LIMS

To this point in the whitepaper, we have talked at length about what an ideal LIMS ought to do, and will later examine specific LIMS implementations within forensics laboratories. Thus, an entire decision support framework has been created for the forensics laboratory wanting to install, update, or replace an existing LIMS package. In the absence of building from scratch, a laboratory must make trade-offs occasionally with respect to aspects of any technical information system, and LIMS is no exception. In the event that a laboratory wanted to explore the myriad of LIMS vendors (or at least the feature sets they offer), we have provided Appendices D and E.

Appendix D covers forensic LIMS vendors in detail, and provides for a side-by-side feature analysis, as well as contact information where given by the vendor. Appendix D also provides a brief review of non-forensic LIMS vendors. Appendix E provides an in-depth review of 5 forensic-specific LIMS vendors,

This analysis of existing products, based upon their published information, provided the research with a baseline of functionality that we then further explored in the field portion of this research.

IN SITU EXAMINATION OF LIMS IMPLEMENTATIONS

An important portion of the information for this study comes from our observation of numerous individual labs and structured discussions with a variety of employees in these facilities. This qualitative portion of our research provides us with two very important types of information: it tells us about the different types of lab environments utilizing LIMS, and also allows us to examine a variety of LIMS that frequently only exist at a particular location (e.g., many LIMS implementations are developed in-house, and information about them is only available in the lab in which they are used).

In order to observe a wide variety of labs and interview a broad range of lab personnel, the research team visited numerous labs throughout the Midwest to fulfill this component of our research. At each location, we met with the management team and with numerous scientific, technical, and administrative employees in semi-formal information gathering sessions. In all instances, we found the lab personnel to be highly engaged in their work and also willing to help us develop information for this project.

Lab Structure and LIMS

One of the most important factors that we found among our visits to labs was the significant impact that the *size* and resulting operational differences of the labs had on the way that LIMS implementations are used. These structural differences represent one of the most important considerations in the selection or development of an effective LIMS.

Absolute size

Regardless of how a lab is structured, its size (as measured in numbers of employees) is a key factor in determining the purpose of the LIMS, irrespective of its componentry or specific functional capabilities. What we found in our visits was that large labs demand the LIMS to organize the operation and running of the laboratory, and to be every bit as effective in this task as in its more traditional task of tracking evidence within the laboratory. More specifically, when a laboratory reaches a critical size, lab personnel are unable to each be intimately familiar with all of the work that is going on in the lab and therefore require some sort of organizing tool to help manage the workload of the facility. This is not to say, however, that the LIMS installed at large facilities have any unique or different componentry for assisting in their more complex environment; rather, the larger labs appear to use the tools their LIMS implementation provides to try and assist in the administration of this more complex work environment.

From an administrator's perspective in a large forensics laboratory, a LIMS implementation helps track the work of multiple analysts in each area, and aids in the management of the enormous amount of activity taking place at any given time. This is not to say that small lab administrators are immune from workflow and workload management issues, but rather, that the larger lab administrators are more dependent on the LIMS to aggregate the information necessary to provide or maintain effective administration of the lab. As reflected in management, scientists in larger labs are more likely to need the LIMS to track their "ownership" of evidence and to help them manage the complexities of

prioritization schedules and collateral analyses. While the work environment of smaller labs is correspondingly complex, the smaller number of scientists and managers actually provides for a richer communication environment in proportion to the complexity in the laboratory environment, which is to say that "everyone can talk to everyone" and information is efficiently passed among lab staff.

One final characteristic that creates greater LIMS dependence for administrative and workflow tracking in the larger labs is the existence of a layer of evidence technicians or administrative personnel charged with primary responsibility to intake and process (and subsequently return) evidentiary materials. While some of their jobs vary considerably, one general comment that can be made is that the scientist is somewhat more removed from the full context of a case, since in these scenarios the evidence technician is frequently more likely to have had primary contact with the client agency and with the full breadth of materials for a given case. Evidence technicians build the primary case file materials and then pass them along to scientists responsible for each of the analyses for the case. In light of this, the LIMS takes on a greater importance to effectively track and manage this transfer of evidence and information through this additional layer of complexity within the organization.

Differences in Users

As expected, LIMS are used in different ways by different types of lab personnel. Administrators, scientists, evidence technicians, and administrative personnel all used the systems for different purposes and, consequently, reported different expectations about what a LIMS should be able to do.

Administrative Users

The lab manager, assistant manager(s), and area supervisors are generally not working on evidence and therefore seldom use the LIMS to track or process any evidence that they have direct involvement with. Rather, for the administrator, the LIMS's primary function becomes one of ensuring the overall integrity of the evidence management system, as well as the provision of a tool to help manage both scientists and processes within the laboratory. In our discussions at the labs, administrators were particularly vexed by challenges in administrative report generation, especially the kind of ad hoc reports that the administrator might need to prepare for legislators or for district attorneys' offices. This does not mean that managers were not concerned about the way that the LIMS operated for the purpose of evidence tracking in itself, but rather that their personal use of the LIMS was much more as a tool to analyze aggregate information about the evidence analysis process.

Scientific Users

All scientific personnel used the LIMS to some degree to keep track of both the analytical activity and chain of custody centered around evidentiary items with the laboratory. In a laboratory with evidence technicians, the scientist would do less of the primary evidence entry and administrative tracking activity that might otherwise fall within their bailiwick in an environment without specialized evidence technicians. Regardless of the presence or absence of evidence technicians, the scientist entered some information about his or her analyses into the LIMS, and also used the LIMS (or some supporting system) to

generate evidence reports for the courts. In some cases, scientists also used the LIMS to help them perform tasks such as workflow management, upcoming task analysis and scheduling, and case or evidence priority changes. This type of activity on the part of scientists seemed to differ more depending upon lab size (larger labs meant more reliance on LIMS as a self-management tool) and whether the LIMS was even useful as a self-management tool (when the LIMS was designed as a very simple evidence-tracking system, lab personnel frequently had supplementary programs and log books to manage information not held in the LIMS).

Evidence Technicians and Administrative Personnel

The activities of evidence technicians and administrative personnel with the LIMS serves as both the primary and terminal processing of evidence through the lab, respectively. In the largest labs, all evidence is initially processed by evidence technicians, who enter information about the evidentiary materials and then place the materials into primary storage or transport them to scientist assigned to the materials. Likewise, when evidentiary analyses are completed, evidence technicians (or administrative personnel) are tasked with arranging the return of evidence to the originating agency. Because so much of the evidence technicians' time is taken up with evidence management activities, they are perhaps more intimately familiar with the primary functionality of the LIMS than any other member of, or functional group within, the laboratory. Evidence technicians and administrative personnel were primarily concerned with the efficiency and accuracy of data entry into the LIMS and were quite articulate on

their own systems' respective faults and merits. Generally, these personnel were frustrated by anything that created duplicated effort on their part, or that required them to re-enter data that had already been entered by police agency personnel.

LIMS Development

Just as structure plays an important role in the way that LIMS are used, the development context of a LIMS is determinant in both its focus and functional capacity. Simply categorized, LIMS are developed in one of two contexts: they are developed for a specific lab or lab system, or they are commercially developed and are then customized to suit individual labs. Each of these development environments has its advantages and disadvantages, and each yields a different kind of LIMS implementation.

In-house development

Many labs have LIMS that are specifically customized and targeted to meet their needs, or for the needs of other laboratories under the same governance (e.g., labs under a common state agency). There is significant variety among these types of LIMS, both in their functionality and in their development history. A number of labs have LIMS that were developed by programmers and system developers that work for an information technology branch of either the state's justice department or the state itself. While this development environment is not problematic in and of itself, the fact that the system is built, maintained and modified by personnel that have a diminished "ownership" of the mission of the lab seems to be almost universally endemic

within labs that rely on state resources. Respondents indicate that the state provides personnel that are tasked to the LIMS, but that these personnel are frequently off-site and too few in number to prevent backlogs of update and patch activities. Interestingly, in our visit to one county lab, we found that their experience with IT staff provided by the county sheriff's department to be excellent, and a number of respondents indicated that county labs are often more likely to have more connected support for IT (as well as other kinds of support). We were also quite interested to see a LIMS at a state agency that was developed by a private outfit specifically for that agency under state contract; this appeared to be a very effective relationship for the lab and may be a preferable model to state agency development of in-house LIMS.

The LIMS that are built in-house are quite diverse, the only common characteristic being that they are iteratively developed as problems become apparent and as needs arise or change. All IT systems are likely to be tuned over time to gain efficiency and process data more effectively, but the in-house systems are truly evolutionary in their development as labs interact with developers to add or modify multiple features of the system over time. One common problem that results from this, aside from the traditional problems associated with "feature creep", is that there are frequently functions of the system or data queries that can only be effected through fairly indirect and intricate work-arounds. Observing these systems as outsiders, it was interesting to see the facility that lab staff had acquired in achieving these work-arounds. Unfortunately, many personnel were frustrated by the questions that simply could

not be answered by the LIMS, which necessitated numerous secondary databases within the labs to manage information that the LIMS simply could not handle.

Commercial Systems

A number of crime labs have purchased commercially developed LIMS, which creates a very different operating environment with regard to the specification and maintenance of the LIMS itself. With a commercially developed system, the software development team brings with it considerable experience with LIMS operations from other labs' installations and maintenance; this means that the purchasing lab specifies what it will need from a LIMS, but does not have to build a LIMS anew in the way that labs with in-house systems must. While this knowledge on the part of the LIMS developers of other labs' challenges and systems designs is generally beneficial, it does mean that the LIMS must be tailored to fit to the lab rather than be built specifically for it. Although this does not generally create significant challenges for labs first moving to LIMS or laboratories upgrading from very simple LIMS implementations, for labs that have considerable experience with an in-house legacy LIMS, the change in process with a new and different system can create some temporary disturbances in workflow.

The labs that we visited that had commercial systems were generally quite happy with their systems and with the degree of support that they got from their system vendors. We did see some disconnect between what the vendors felt was available in the system and what the clients understood to be there. An

exemplar of this notion came when we spoke with a lab administrator that had developed a remarkably elegant prioritizing database because he could not effectively prioritized analyses with his LIMS. We were quite impressed, and took some screen shots of the program later that day to the LIMS vendor to see what analogous functionality, if any, the vendor could create for the laboratory. After the vendor examined the screenshots and talked with us about what the administrator was trying to do, the vendor indicated that the function was already extant in the LIMS, but that the client's IT administrators had probably not turned it on for him. While a story like this is anecdotal, it does underscore the major benefit of commercial LIMS; because the vendor has relationships with so many different labs over a period of time, most functional requests have appeared and reappeared numerous times and the software then reflects this in its diversity of functionality.

Commercial versus In-house

There is no clear "winner" in this comparison; as we have noted, when sufficient resources are devoted to an in-house development, it can rival or even out-perform the best commercial systems (particularly with regard to its ability to interface with unique local resources, such as local courts' systems and agency evidence systems). This having been said, many of the labs that we visited that had in-house developed systems were performing admirable work with very limited systems and system support. Laboratories with commercial systems, by contrast, seemed to have better service and support and seemed (from our

perspective) to be functioning in a more process-compatible and process-efficient manner.

Process Engineering Issues

LIMS implementations, while traditionally viewed as a target platform or package, provides much more a framework for the laboratory to carry out their evidence analysis processes. The ideal LIMS integrates closely with a laboratory-wide process flow that has been examined, tested for rigor, and streamlined. This requisite examination lends itself to modeling and streamlining the process before a LIMS system is ever selected. As such, we have examined laboratory processes across the Midwest. Appendix A shows the generic processes that take place within any forensic laboratory environment. The path that evidence takes within the laboratory is followed, to allow for a thorough breakdown of the processes surrounding the examination of the evidence. To wit, Appendices B and C demonstrate the process flow surrounding evidence within a laboratory environment that is “tightly-coupled” to a requesting agency, and “loosely-coupled”, respectively. The “coupling” used in this discussion refers to the closeness in process, procedure, or warehousing or acquisition of evidentiary data that occurs between the examining laboratory and requesting agency. The LIMS must allow the laboratory scientists and other employees enough flexibility to perform their routine tasks to exacting standards, yet must also be robust and rigid enough to disallow “out-of-band” evidence handling and processing. Such “out-of-band” control at any stage in the evidentiary handling

process points either to a deficiency in the LIMS or to its integration within laboratory process and procedure.

A LIMS that is well-integrated with laboratory procedure yields enhanced buy-in and cooperation from all levels within the organization. Ideally, as described above, the laboratory processes would be identified, mapped, streamlined, and critical paths and "deadlocks" would be identified. Routinely seen in the field, however, were process models that were unclear, undefined, or ill-defined. As such, LIMS implementations failed to fully take into account the reality of laboratory procedure, coupled with the previous point, made for a good degree of laboratory-driven "bolt-on" solutions to more closely meet with an established (though not necessarily examined or streamlined) process.

LIMS integration with Police Evidence Management Systems (PEMS) and other Requesting Agency Evidentiary Systems

Contingent to any LIMS and process success is the entering of the data that identifies the item(s) of evidence associated with a case into the LIMS. This data entry may be accomplished by a human operator, but a preferable method of entry comes in the form of electronic integration with Police Evidence Management Systems (PEMS). In the former case, manpower is being used to re-type police forms that may be electronic in nature (but may also be handwritten), with no clearly-defined standard available. In effect, if a laboratory serves several different departments, it may find itself entering data with no consistent format defined, thus drastically increasing cognitive load upon the operator while simultaneously increasing the possibility for error. This inaccurate

description captured upon initial evidence presentation then flows through the LIMS and laboratory, and has a “ripple effect” as this bad data is cleaned and corrected by forensic scientists. This, quite clearly, is an inefficient mechanism to deal with information flow in the laboratory – furthermore, such capture of “bad” data could have possible legal implications that come with data manipulation.

The second – and preferred – method of evidence data entry comes with data format integration with the requesting authority’s PEMS. At its most simplistic, systems can make use of a floppy disk or other removable media to provide either an unformatted text description of all pertinent fields in the police report, or text data that is encapsulated within meta-data that describes this text. Of specific note with respect to formatting is the second notion of data encapsulation, which carries not only data but also meta-data that describes the data and its integration within the entire document. LIMS and PEMS integration is facing, and will continue to face, the same challenges that were seen in electronic commerce with the coming of Electronic Data Interchange (EDI). Specifically, the modern-day metaphor that may be of interest to any laboratory looking to improve data acquisition and quality is eXtensible Markup Language (XML). XML is a format that carries both data (text fields) and meta-data (the description of just *what* the text field represents). As such, using XML makes for a simple data interchange between dissimilar systems (such as PEMS and LIMS inherently are) through the provision of “hooks” which provide data access and meaning to third-party applications.

In our examination of various laboratories in the Midwest, PEMS integration came in two gross forms: full integration with one and only one PEMS data layout (e.g. one agency), or none at all. Just as was the case in EDI and the early days of electronic commerce, PEMS and LIMS integration, through XML, carries with it the promise of massively reduced data input errors and improved check-in time for the requesting agency. Indeed, it is also possible, when dealing with *data* as opposed to *carbon paper*, to allow laboratories to "pull" case information from an agency computing system that has been hardened and secured for this purpose. Such a mechanism eliminates the need for the responding officer to carry anything other than the evidence and associated paraphernalia that is bound to the case being examined, and can be made more secure than traditional paperwork.

Within-Process Use of Evidence Technicians

Forensics laboratories have to process incoming evidence; this is an inescapable fact that comes with evidence examination. In light of this, some laboratories that we examined hired specialists – evidence technicians – who were charged with the duty of acting as data entry operators. Additionally, these evidence technicians provided the daily laboratory interface with outside agencies, and in some instances determined the laboratory department that should initially receive the evidence. This, in turn, frees the forensics specialists to interact with the system *only as it relates to their scientific inquiry and report writing* while keeping a tight focus on process, procedure, and scientific rigor. Additionally, many laboratories operating in this manner develop an insight into

and expertise with the local LIMS that comes as a result of the daily evidence technicians' use. As such, these evidence technicians have the expertise and technical ability to field phone calls or other inquiries regarding specific case progress, thus further ensuring that the forensics scientists are left largely to the business of scientific inquiry.

In smaller laboratories, however, the trend seen in the Midwest was that examiners were expected to "wear many hats", including that of data entry clerk and case contact point. While this makes for a day fraught with interruption for the forensics examiners, it also may be argued that this approach gives a more holistic, end-to-end understanding of the processes involved within the evidentiary lifecycle. However, the exemplar laboratory examined for this scenario had no clear definition of process compared to some of its larger brethren, and the wearing-of-all-hats approach actually yielded out-of-band evidence management because it was "easier" and because the current LIMS implementation "forced" the examiners to touch both evidence and location "too often". As such, strict chain-of-custody is somewhat more dubious in these types of environments, but this weakness is often overcome by the lack of personnel – it is entirely possible, for instance, to find evidence within a co-worker's space (even though the LIMS reports this evidence as being in the vault) in an environment this small.

Even in light of the above counter-point to dedicated evidence technicians, it is still advisable for a laboratory to maintain some employees as part-time, cross-trained, or (preferably) dedicated evidence technicians. This, from our *in*

situ examination, provides both an environment of improved data and process quality, *and* also allows for expansion of scale within the laboratory environment that is not possible without this dedicated position.

Evidence control as a driver of chain-of-custody and barcoding

"Evidence control" in modern forensics laboratories has come a long way from a paper-driven check-in/check-out system, but it is important to understand that the electronic counterpart acts not so much a *replacement*, but a *metaphor* for this classic system. As such, the level of scrutiny that the end-to-end process receives should not change just because the modality of the system has changed; indeed, with the potential to *disaggregate* data from evidence (e.g. a cessation in direct evidence tagging), evidence control processes and their corresponding chain-of-custody must be vastly improved.

In much the same manner that volume drives laboratory size, which in turn impacts internal processes and the decision to hire dedicated evidence technicians, so too does both evidence volume and disparity of requesting agency drive how this evidence is initially taken in, and later kept, within the laboratory environment. Again, the processes utilized in a small laboratory are inherently restrictive – correspondingly, evidence locations tend to be highly aggregative in nature, e.g. "vault". This comes as a counter-point to one of the larger and more diversified laboratories in the Midwest that were examined which provided for *both* bar-coded evidence *and* location tagging, which in turn provides for very granular information regarding the location of any given piece of evidence, e.g. "incoming vault, section E, shelf A1". This granular approach

scales well while also making it possible to quickly and easily find any evidence under examination within the laboratory. As such, chain-of-custody questions are much more forcibly answered in court examinations through being able to pinpoint, *in exacting detail*, the location of evidence within the laboratory. Additionally, the location of evidence, in this instance, is *strongly* associated with the department or person who is examining said evidence. This is an important point to grasp, as it provides positively corroborating evidence that chain-of-custody is being fully maintained at every step in examination by providing a more direct tie between item location and examiner.

As location and examiner are vital to provide a full chain-of-custody picture, any increase in the ability to bind the two is imperative. However, this comes at the potential perceived "cost" of an examiner being forced to ensure that they electronically bind the item to themselves at each stage in the examination process, and finally bind the item to the "finished" vault after the report has been written. This notion was met with great resistance in the smallest laboratory, discussed above, as it was "cumbersome" and "took time away from examination". A globally-acknowledged solution comes with increased use of barcodes and wireless barcode readers, whereby an examiner is able to quickly scan their badge and then an item to "bind" this set of evidence to the examiner. This solution releases the examiner from the computer terminal and makes the establishment and maintenance of a rigorous chain-of-custody painless. Such a solution scales well and also ensures that item location is known at all times; if the process and LIMS are designed to make use of this

solution, then evidence control is more tightly constrained and met with little employee resistance. In the future, RFID provides an even more promising extension of this concept through the ability to walk through a portal- or area-based reader without having to scan individual items or a badge with a handheld reader. This approach makes employee buy-in implicit, and decreases cognitive load to nil, as the approach is completely transparent to the forensics examiner.

Other Information System Issues

In talking with lab personnel about LIMS, two significant associated issues became apparent: first, that lab personnel are clearly interested in a paperless environment, and second, that there is a clear need for systems designed to help manage the lab itself, and not just it's evidence.

The paperless imperative

In an environment where work backlogs are the norm, the notion of duplicating *any* effort is not attractive to lab personnel. Hence, the attractiveness of LIMS that automatically generates reports, creates daughter evidence forms, and the like is based on the workers' desire to process evidence as efficiently as possible. Numerous respondents indicated that a paperless system, where their notes and analytical instrument readings would be automatically transcribed into the LIMS and its associated electronic casefile would be a very useful addition to their labs' systems. Personnel differed on their vision of a paperless environment, but most seemed to see utility in entering information one time and

having it captured by the LIMS, and this point was made particularly salient with regard to the peer review process that must occur within labs.

Laboratory Information Management Systems

Most LIMS are designed primarily to ensure the chain of custody of evidentiary materials, and to capture and manage information on the analyses performed on those materials. All LIMS perform that function, although some do so not as elegantly as others. However, laboratory managers have increasingly come to rely on the LIMS as a tool to manage the lab itself, and in this scenario the LIMS becomes a proxy tool for processes within the laboratory such as personnel management, equipment management, or supply purchasing. Some LIMS do an admirable job of providing information that supports the management function, but even the best of them are not really designed for this role. It became clear to us in talking to lab managers and administrators that there is a role for a purely managerial system (or advanced sub-system) to assist in the increasingly complex task of managing a modern crime lab. Such a system would assist in such activities as personnel management, site management, budgeting, and other daily management activities.

QUANTITATIVE RESEARCH

The previous sections covered our information gathering process, and the insights it gave, with significant help through the donation of time and insights from forensics laboratory directors and personnel. This kind of qualitative research – focus groups, in our case – yields information of great value, but is often difficult to objectively examine and generalize to a larger population. To

this end, we also conducted quantitative research, consisting of an online survey that was completed by forensics lab personnel. Surveys can yield information that is useful in both in breadth and scale, and also allows respondents to be more forthcoming because of the survey's anonymity. This survey method typifies much of the research in information system analysis, but we wanted to take this opportunity to go one step further in our survey through the use of *conjoint* methodology.

An Overview of Conjoint Analysis

The conjoint analysis technique is a statistical methodology that has traditionally been used in marketing as a means of quantifying consumer preferences for new products or services (Huber, 1987). In most cases, a product consists of several components or attributes that can be varied in different potential configurations of the product. For example, a product might be designed with a certain price, appearance, or performance capability that may be attractive to some people but less attractive to others. Conjoint can be useful in quantifying the utility that a consumer, user, or other stakeholder has for one or more of the attributes of a product, service, or system. By allowing the analyst to quantify the utility of the product features, an optimum "bundle" of these features can be identified and used to design the "preferred product." To date, conjoint has primarily been used to examine stakeholder preferences for consumer-oriented products in a more traditional marketing context (e.g., a consumer goods manufacturer such as Proctor and Gamble identifying the utility of features present in Crest toothpaste). This project uses conjoint analysis in a

novel way by applying this tool to examine a different type of product, information systems used by stakeholders in forensics laboratories (i.e., LIMS).

Conjoint is a multivariate technique that assumes that consumers of a product will evaluate the relative value of the product by combining the utility of each relevant attribute of the product in an evaluative process. A significant amount of research has been reported that has examined the use of conjoint in identifying the market potential for new or "new and improved" products (Cattin & Wittink, 1982; Wittink, Vriens, & Burhenne, 1994). A common application for conjoint analysis has been in the new-product development process where features of a potential product are combined and altered, dropped and added, all with the goal of identifying an optimal mix of features for the new product offering (Green & Krieger, 1991; Hauser & Simmie, 1981; Mahajan & Wind, 1992; Moore, Louviere, & Verma, 1999; Page & Rosenbaum, 1987; Urban, Hauser, & Roberts, 1990; Urban, Weinberg, & Hauser, 1996; Wind, Green, Shifflet, & Scarbrough, 1989; Wittink, Vriens, & Burhenne, 1994). In this context, conjoint has been used to identify the utility of product features, to develop product design tradeoffs, to set marketing services and mix, and to perform competitive benchmarking (Weinberg, 1990). In addition, product pricing and market segmentation are also common applications of conjoint analysis (Green & Krieger, 1989, 1992; Hauser & Simmie, 1981).

Given this, conjoint was chosen as a tool to use in this project to evaluate laboratory information management systems (LIMS), as information systems are, in many ways, no different than any other product. For example, a set of LIMS

features can be presented to a lab technician, an analyst, or a forensics laboratory manager as a *product* consisting of numerous attributes or systems features. Thus, these attributes can be varied and mixed to represent different configurations of potential LIMS. By doing this, the relative importance of LIMS features can be quantified and used to identify the characteristics that would be important to consider in building or buying a new LIMS.

Conjoint Methodology

Numerous studies have been conducted to study different methodologies and statistical techniques for conducting and analyzing conjoint projects (Akaah & Korgaonkar, 1983; Akaah, 1991; Agarwal, 1988b; Agarwal & Green, 1991; Green, Krieger, & Agarwal, 1991; Johnson, 1991; Orme, 1999; Tumbush, 1991). Of most importance to this project is the research that has focused on the different approaches used to collect stakeholder preferences. When compared to manual approaches, computer-based approaches to conjoint have generally demonstrated that a larger number of product attributes can be examined, allowing much more complex products to be evaluated. Thus, a computer-based conjoint package marketed by Sawtooth Software, Inc., was selected to collect surveys and analyze the survey responses (visit www.sawtoothsoftware.com for more information).

Sawtooth Software, Inc., markets three computer-based conjoint tools. Each tool has advantages and disadvantages and is focused on particular types of problems or analyses. Choice-Based Conjoint (CBC) creates a choice scenario that is designed to mimic the purchase process (Sawtooth Software,

Inc., 2005a). CBC differs from other conjoint analysis techniques in that the respondent is asked to express their preferences by choosing from "sets of concepts." In this way, the choice-based evaluation process is most similar to the process buyers actually engage in when making purchasing decisions. CBC is most frequently used to examine relationships between price and product demand, and is most useful when the relationship between price and demand differs from brand to brand. Also, CBC is most appropriate when a small number of product features are to be examined by a large number of respondents (e.g., several hundred consumers).

Conjoint Value Analysis (CVA) is modeled after traditional, non-computer based conjoint by designing a survey that asks respondents to consider all product features simultaneously (Sawtooth Software, Inc., 2005b). CVA is useful when the researcher is not interested in measuring interactions and when sample sizes are not large enough to use CBC. In addition, an advantage of CVA over the other Sawtooth Software products is that it can be used when both computer-based and paper-and-pencil-based survey collection techniques need to be used (e.g., when data are collected in a venue where computers are available for some respondents but not others). The disadvantage of CVA and CBC is that both techniques are, for all practical considerations, limited to problems where a relatively small (e.g., 4-6) number of attributes are considered.

The third conjoint product, adaptive conjoint analysis (ACA), is designed to allow the researcher to conduct surveys where the limitations present in the other conjoint methods might otherwise preclude the use of the conjoint technique. To

do this, ACA *adapts* the interview for each respondent by learning about the value that each respondent has for each product attribute and then focusing questions on areas that are of importance to that individual respondent. In this way, the ACA tool is able to reduce the number of questions within the survey. Therefore, a principle advantage of ACA is that it enables the researcher to examine product offerings that include many more attributes than would be feasible to examine using manual approaches (Johnson, 1987). ACA has demonstrated reliability and, in many cases, superiority to other approaches for the types of analyses being performed in this project (Agarwal & Green, 1991).

Because LIMS include many capabilities and features that need to be simultaneously considered in the evaluation of their relative importance, ACA was selected as the preferred analysis tool for this project. Specifically, ACA offers several advantages that justify its use for examining complex products such as information technology. These include:

- ACA interviews can include up to 30 features or attributes
- Each feature or attribute can include a large number of levels (i.e., up to 15 levels)
- ACA interviews can be conducted using a web-based delivery tool (Sawtooth Software's SSI-Web)
- Based on these criteria, a survey was developed using the Sawtooth Software, Inc., ACA analysis tool.

Conjoint Survey Structure

The ACA survey includes four major sections, each of which is used to examine or calibrate particular facets of the respondent's preference structure (Sawtooth Software, 2002). The first section of the survey is the *Preference for Levels* section where the respondent rates their preference levels by assigning a rating score on a 7-point scale. For some attributes, a preference may be obvious and the software can be set so that the respondent is not queried about their preference score for that attribute. For example, in this survey an attribute such as *screen manipulation* included two levels (*the user could open more than one screen at a time* or *the user could only open one screen at a time*) that were determined to be obvious in preference for all users. In this case, the survey was set with the assumption that users would prefer to be able to open multiple screens simultaneously.

The second section of the survey is designed to identify *Attribute Importance* (Sawtooth Software, 2002). The purpose for this section is to determine how important each attribute is to each respondent. To do this, the survey doesn't merely ask the subject to rate the importance of the attribute; rather, the survey poses a question that asks the respondent to evaluate the importance of an attribute in terms of the relative difference in the levels for each attribute. This measure of importance serves two purposes. First, if an attribute is found to not be important it may be eliminated from additional evaluation. Second, the importance measure provides information that can be used to

determine an initial estimate of the respondent's utility for each attribute (Sawtooth Software, 2002).

The third section consists of a set of *Paired-Comparison Trade-Off Questions* (Sawtooth Software, 2002). The paired-comparison section is the core of the conjoint process and is designed to force the respondent to make tradeoffs between pairs of grouped attributes. For each comparison, the respondent is shown two groups of attributes that are each designed to represent a hypothetical LIMS that consists of a set number of product attributes. For each grouping, the same set of attributes is considered, but each hypothetical product contains different levels or values for each attribute. The respondent is asked to rate which grouping is preferred by entering a rating score indicating the degree to which he or she prefers each hypothetical product. Every time the respondent completes a paired-comparison question, the overall estimate of the respondent's utility for each attribute is updated. In ACA, this updated utility score is used to adjust the quality and relevance of subsequent paired-comparison questions (Sawtooth Software, 2002).

The fourth section consists of a set of *Calibrating Concepts* that are designed to refine the utilities obtained in the earlier part of the survey (Sawtooth Software, 2002). These refined utilities are used in the analysis of the conjoint data and for running purchase simulations. The survey will pick the attributes that are determined to be most important based on earlier responses from the subject. The combination of attributes is selected to create a range of profiles, from very unattractive to very attractive, based upon the respondent's preference

structure. The survey asks the respondent to estimate the "likelihood of buying" each combination of attributes by entering a numeric value that represents the "probability" that he or she would buy the product.

The final section of the survey consists of a series of questions that asks about contextual information associated with the respondent. This information includes topics such as the structure and size of the organization, its culture and innovativeness, and demographic information about the respondent.

Research Procedures

The survey was developed after conducting the site visits discussed earlier in the report. Based on the interviews, focus groups, and observations made during visits the researchers identified a list of attributes (i.e., systems features) that were determined to be most relevant to stakeholders. The list of attributes and the levels for each attribute are presented in Appendix F. Once the attributes and levels were identified, they were evaluated and refined in an iterative process by a panel consisting of the researchers, members of the MFRC, and MIS faculty members in the College of Business at Iowa State University. The focus of this refinement process involved examining the relevance of the attributes and the wording of attribute levels.

The purpose of developing the survey was to deliver it to personnel in forensics laboratories to elicit information about preferences and attitudes about LIMS and gather information about the respondent's laboratory. The pool of respondents selected for participation in the survey was identified by the MFRC and consisted of a set of forensics laboratories that had previously agreed to

participate in the research project. The laboratories that were included in the research sample follow below:

- Forensic Science Center at Chicago
- Hennepin County (MN) Sheriff's Office Crime Laboratory
- Illinois State Police
- Indiana State Police Laboratory Division
- Indianapolis-Marion County Forensic Services Agency
- Johnson County (KS) Crime Laboratory
- Kansas Bureau of Investigation
- Kansas City (MO) Police Department Crime Laboratory
- Nebraska State Patrol Crime Laboratory
- South Dakota State Forensic Laboratory
- State of Michigan Department of State Police, Lansing Forensic Laboratory
- Wisconsin State Crime Laboratory, Milwaukee

To obtain participation by laboratory personnel, a solicitation letter (Appendix G) was sent to the laboratory directors at each of the laboratories. The letter asked the director to request that laboratory personnel complete the survey. The letter was sent to the laboratory directors on September 7th, 2005, with a request that personnel complete the survey by September 21st, 2005. The last completed and usable survey was submitted on September 23rd.

Results

A total of 92 forensic professionals responded to the survey. In addition to the conjoint survey and information about respondent perceptions, data were also collected about respondent demographics, the respondent's position and responsibilities, and the characteristics of the respondents' laboratories. The average age of the respondents was 40.4 years and on average respondents had 11.7 years of experience in the forensics field. The number of females is 47 (51.1%) and the number of males is 45 (48.9%). Respondents were asked to indicate the type of position they held within the laboratory. Respondents were classified into one of three categories, management, analyst/scientist, or evidence technician/clerical. Since respondents could check all job responsibilities that applied, several respondents indicated that they had overlapping responsibilities; for example, functioning as both a supervisor and analyst or as an analyst and evidence technician. In these instances, the respondent was classified into the job classification that would typically be considered higher in the organizational structure (e.g., a manager/bench scientist would be classified as a manager or an analyst/evidence technician would be classified as an analyst). A total of 22 respondents (23.9%) were classified as clerical/evidence technicians, 51 respondents (55.4%) were classified as analyst/scientists, and 18 respondents (19.6%) were classified as managers/supervisors.

The respondents were not asked for information that would make them individually identifiable, so no specific information about the laboratory for which

they worked was requested. However, information about the size of the laboratory was collected. The average for the lab size was 100.1. However, this average hides the fact that there were actually three distinct clusters of laboratories based on their size: *small* laboratories that included 30 or fewer personnel, *medium-sized* laboratories that included more than 30 but fewer than 100 personnel and *large* laboratories that included more than 100 personnel. The results indicate that there are 17 small-sized laboratories (18.5%), 47 medium-sized laboratories (51.1%), and 28 large-sized laboratories (30.4%). Information about the types of LIMS currently in use was also collected. The results show that laboratories used a variety of products, some of which were built in-house and some of which were purchased from vendors (see Table 2). To facilitate examination of the conjoint data, the laboratories were segmented by whether they had a commercially-available system, or a system built in-house.

Table 2 – Forensic LIMS Vendors or Developers

Vendor/Source	Number
BEAST	8
FTI/BARD	31
In-House	45
Unknown	8
Total	92

Conjoint Analysis

The conjoint component of the survey was analyzed by first examining the respondents' preference structure in aggregate. The conjoint survey produces results that provide two types of information: 1) the conjoint relative utility of the levels within each attribute (also called the *part worth* of the level) and 2) the importance of the attribute or feature of the LIMS. The conjoint relative utilities

are scaled to an arbitrary additive constant within each attribute (Orme, 2002). The scales are designed to sum to 0 within each attribute but are completely arbitrary; therefore, the scores can only be compared in a relative sense. For example the utilities for Pre-Logging are as follows:

- The LIMS supports Pre-Logging by integrating with Agency Evidence Management Systems for initial data input 31.41
- The LIMS supports the importation of Pre-Logged Data 24.89
- The LIMS does not support importation of Pre-Logged Data -56.29

In this case, we can only say that the first level (integrating with agency evidence management systems) is preferred to the second level (supporting pre-logging) and that the second level is preferred to the third level (no support for pre-logging). It does not speak to any strength of priority. For example, you cannot say that the relative preference over the first to the second is any more or less than the relative preference between the second and third even though the numeric values appear so. For the attribute importance, scores are scaled to a 100-point scale with each value representing the importance of each factor in relation to the total for all attributes. The importance for each attribute is calculated by considering the difference that each attribute makes in the total utility of a packaged LIMS. The value of this *difference* is determined by looking at the range in each attribute's utility values. A percentage value for the ranges is calculated, obtaining a set of attribute importance values that add to 100. These importance values can be interpreted as a percentage of the total importance that each attribute possesses.

The utilities and importance scores for the responses to the conjoint survey are included in Appendix F. The results in the following section includes a summary of these data for the aggregate of all respondents as well as within segments. The segments were examined using three segmentation variables: Laboratory Size, Respondent Position, and Source of Existing LIMS.

Conjoint Analysis: Aggregate Results

The results for the *aggregate* of all respondents are given in Appendix F. The sorted preferences based on importance are summarized in Table 3. The results of the aggregate analysis show that *Daughter Evidence,*

Management Analyst Report Preparation, Chain of Custody Transfer, System Command Navigation, and Generation of Analyst Summary Statistics are the five most important LIMS features. Alternatively, Interface with Analytical Equipment, Terminal Mobility, Analyst Assignment, Asset Management, and Personnel Certification Management are the LIMS features or capabilities given the least importance by respondents. Based on the utilities and the most important attributes, an ideal system would include the feature set displayed in Table 4.

Table 3 – *Importance*: Aggregate Response

	Total
Daughter evidence	8.82
Management and Analyst Report Preparation	8.31
Chain of Custody Transfer	8.00
System Command Navigation	6.50
Generation of Analyst Summary Statistics	6.19
Pre-logging	6.07
Data Entry	6.01
Case Prioritization	5.51
Screen Manipulation	5.18
Case Evidence Status	5.15
Court system status	5.13
Case Grouping	5.08
Query Access to Management Data	4.77
Interface with analytical equipment	4.43
Terminal Mobility	4.13
Analyst Assignment	4.12
Asset Management	3.34
Personnel Certification Management	3.26

Table 4 - Ideal LIMS Based on Aggregate Response

- Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case
- High level of Data Entry automation
- When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes
- Supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation
- The LIMS allows analysts to create or access Summary Statistics showing performance, backlog, and other case information

Conjoint Analysis: Laboratory Size

Small Laboratories. Results for the segment of *Lab Size* are shown in Appendix F. The sorted preferences based on importance are summarized in Table 5. The results of the analysis shows that for small laboratories, *Daughter Evidence*, *Chain of Custody Transfer*, *Management and Analyst Report Preparation*, *Pre-logging*, and *System Command Navigation* are the five most important LIMS features. In the same small laboratories, *Analyst Assignment*,

Case Evidence Status, *Interface with analytical equipment*, *Personnel Certification Management*, and *Asset Management* are the least important LIMS features or capabilities. Based on the utilities and the most important attributes, an ideal system for a "small" laboratory (a laboratory employing under 30 individuals) would include the features shown in Table 6.

Table 5 - Importance for Small-Sized Laboratories

	Total
Daughter evidence	11.04
Chain of Custody Transfer	8.50
Management and Analyst Report Preparation	7.83
Pre-logging	6.74
System Command Navigation	6.40
Case Grouping	6.33
Query Access to Management Data	5.93
Generation of Analyst Summary Statistics	5.84
Case Prioritization	5.66
Court system status	5.65
Data Entry	5.35
Screen Manipulation	4.56
Terminal Mobility	4.03
Analyst Assignment	3.87
Case Evidence Status	3.79
Interface with analytical equipment	3.66
Personnel Certification Management	2.60
Asset Management	2.22

Table 6 - Ideal LIMS for Small-Sized Laboratories

- Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case
- When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes
- The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.
- The LIMS supports Pre-Logging by integrating with Agency Evidence Management Systems for initial data input
- Supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation

Medium-sized laboratories. The sorted preferences based on importance for medium-sized laboratories (laboratories having between 30 and 100 employees, non-inclusive) are summarized in Table 7. The analysis of responses for medium-sized labs shows that *Management and Analyst Report Preparation, Daughter Evidence, Chain of Custody Transfer, System Command Navigation, and Generation of Analyst Summary Statistics* are the five most important LIMS features. Alternatively, *Query Access to Management Data*, *Terminal Mobility*, *Asset Management*, *Analyst Assignment*, and *Personnel Certification Management* are the least important LIMS features or capabilities. Based on the utilities and the most important attributes, an ideal system for a medium-sized laboratory would include the features shown in Table 8.

Table 7 - Importance for Medium-Sized Laboratories

	Total
Management and Analyst Report Preparation	8.54
Daughter evidence	7.86
Chain of Custody Transfer	7.60
System Command Navigation	6.36
Generation of Analyst Summary Statistics	6.05
Case Prioritization	5.88
Data Entry	5.84
Screen Manipulation	5.82
Case Evidence Status	5.49
Pre-logging	5.36
Case Grouping	5.15
Interface with analytical equipment	5.05
Court system status	4.76
Query Access to Management Data	4.72
Terminal Mobility	4.29
Asset Management	3.93
Analyst Assignment	3.70
Personnel Certification Management	3.61

Table 8 - Ideal LIMS for Medium-Sized Laboratories

- The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.
- Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case
- When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes
- Supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation
- The LIMS allows analysts to create or access Summary Statistics showing performance, backlog, and other case information

Large-sized laboratories. The sorted preferences based on importance for large-sized laboratories are summarized in Table 9. The results of the analysis for large laboratories (having more than 100 employees) shows that *Daughter Evidence*, *Chain of Custody Transfer*, *Management and Analyst Report Preparation*, *Pre-logging*, and *System Command Navigation* are the five most important LIMS features. Conversely, *Query Access to Management Data, Terminal Mobility, Interface with Analytical Equipment, Personnel Certification*

Management, and Asset Management are the least important LIMS features or capabilities. Based on the utilities and the most important attributes, an ideal system for a large-sized laboratory would include the features presented in Table 10.

Table 9 - Importance for Large-Sized Laboratories

	Total
Daughter evidence	9.09
Chain of Custody Transfer	8.38
Management and Analyst Report Preparation	8.21
Pre-logging	6.84
System Command Navigation	6.80
Data Entry	6.70
Generation of Analyst Summary Statistics	6.62
Court system status	5.44
Case Evidence Status	5.41
Analyst Assignment	4.97
Case Prioritization	4.80
Screen Manipulation	4.48
Case Grouping	4.20
Query Access to Management Data	4.15
Terminal Mobility	3.94
Interface with analytical equipment	3.85
Personnel Certification Management	3.08
Asset Management	3.03

Table 10 - Ideal LIMS for Large-Sized Laboratories

- Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case
- When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes
- The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.
- The LIMS supports Pre-Logging by integrating with Agency Evidence Management Systems for initial data input
- Supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation

Conjoint Analysis: Personnel Level

Clerical/Evidence Technicians. The results for the segment of *Personnel Level* are displayed in Appendix F. The sorted preferences based on importance are summarized in Table 11. The results of the analysis shows the five most important LIMS features are *Daughter Evidence*, *Chain of Custody Transfer*, *Management and Analyst Report Preparation*, *Pre-logging*, and *Data Entry* for evidence technicians and clerical employees. *Interface with Analytical Equipment*, *Asset Management*, *Terminal Mobility*, *Case Evidence Status*, *Personnel Certification Management* are the least important LIMS features or capabilities. Based on the utilities and the most important attributes, an ideal system for evidence technicians and clerical employees would include the features shown in Table 12.

Table 11 - Importance for Clerical / Evidence Technicians

	Total
Daughter evidence	9.24
Chain of Custody Transfer	7.88
Management and Analyst Report Preparation	7.20
Pre-logging	6.95
Data Entry	6.59
System Command Navigation	6.45
Case Grouping	6.19
Generation of Analyst Summary Statistics	6.11
Query Access to Management Data	5.79
Screen Manipulation	5.66
Case Prioritization	4.83
Analyst Assignment	4.31
Court system status	4.12
Interface with analytical equipment	4.11
Asset Management	3.92
Terminal Mobility	3.82
Case Evidence Status	3.80
Personnel Certification Management	3.05

Table 12 - Ideal LIMS for Clerical / Evidence Technicians

- Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case
- When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes
- The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.
- The LIMS supports Pre-Logging by integrating with Agency Evidence Management Systems for initial data input
- The LIMS provides a high level of Data Entry automation

Analysts/ Scientists. The sorted preferences for Analysts and Scientists based on importance are summarized in Table 13. The results of the analysis show that for analysts and scientists *Management and Analyst Report Preparation*, *Daughter Evidence*, *Chain of Custody Transfer*, *System Command*

Navigation, *and Pre-logging* are the five most important LIMS features. Alternatively, *Interface with Analytical Equipment*, *Terminal Mobility*, *Analyst Assignment*, *Asset Management*, *Personnel Certification Management* are the least important LIMS features or capabilities. Based on the utilities and the most important attributes, an ideal system for evidence analysts and scientists would include the features shown in Table 14.

Table 13 - Importance for Analysts / Scientists

	Total
Management and Analyst Report Preparation	9.13
Daughter evidence	8.95
Chain of Custody Transfer	7.80
System Command Navigation	6.93
Pre-logging	6.55
Generation of Analyst Summary Statistics	6.13
Data Entry	5.96
Case Prioritization	5.91
Court system status	5.45
Case Evidence Status	5.25
Screen Manipulation	4.82
Case Grouping	4.65
Query Access to Management Data	4.49
Interface with analytical equipment	4.48
Terminal Mobility	4.11
Analyst Assignment	3.91
Asset Management	2.86
Personnel Certification Management	2.64

Table 14- Ideal LIMS for Analysts / Scientists

- The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.
- Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case
- When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes
- Supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation
- The LIMS supports Pre-Logging by integrating with Agency Evidence Management Systems for initial data input

Managers. The sorted preferences for managers based on importance are summarized in Table 15. The results of the analysis shows that the five most important LIMS features for managers are *Chain of Custody Transfer*, *Daughter Evidence*, *Management and Analyst Report Preparation*, *Generation of Analyst Summary Statistics*, and *Case Evidence Status* . *Analyst Assignment*, *Terminal Mobility*, *Query Access to Management Data*, *Asset Management*, and *Pre-logging*, conversely, are the least important LIMS features or capabilities. Based on the utilities and the most important attributes, an ideal system for managers would include the features shown in Table 16.

Table 15 - Importance for Management

	Total
Chain of Custody Transfer	8.44
Daughter evidence	8.01
Management and Analyst Report Preparation	7.43
Generation of Analyst Summary Statistics	6.56
Case Evidence Status	6.45
Screen Manipulation	5.78
Court system status	5.52
Data Entry	5.48
Case Prioritization	5.20
System Command Navigation	4.96
Personnel Certification Management	4.93
Interface with analytical equipment	4.89
Case Grouping	4.81
Analyst Assignment	4.70
Terminal Mobility	4.65
Query Access to Management Data	4.21
Asset Management	4.08
Pre-logging	3.87

Table 16 - Ideal LIMS for Managers

- When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes
- Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case
- The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.

Conjoint Analysis: LIMS Vendor/Source

In-house built LIMS. The results for the segment of *vendor* are shown in Appendix F. The sorted preferences based on importance for respondents with in-house systems are summarized in Table 17. The results of the analysis shows that for respondents with LIMS developed in-house, the five most important LIMS features are *Daughter Evidence*, *Management and Analyst Report Preparation*, *Chain of Custody Transfer*, *Pre-logging*, and *Data Entry*. Alternatively, *Analyst Assignment*, *Interface with Analytical Equipment*, *Terminal Mobility*, *Asset Management*, *and Personnel Certification Management* are the least important LIMS features or capabilities for this group. Based on the utilities

and the most important attributes, an ideal system for respondents with in-house LIMS implementations would include the features shown in Table 18.

Table 17 - Importance for Respondents with In-House Systems

	Total
Daughter evidence	9.81
Management and Analyst Report Preparation	8.32
Chain of Custody Transfer	7.92
Pre-logging	6.63
Data Entry	6.50
System Command Navigation	6.37
Generation of Analyst Summary Statistics	6.35
Court system status	5.52
Case Prioritization	5.19
Case Grouping	5.00
Query Access to Management Data	4.73
Screen Manipulation	4.70
Case Evidence Status	4.68
Analyst Assignment	4.32
Interface with analytical equipment	4.27
Terminal Mobility	4.09
Asset Management	2.93
Personnel Certification Management	2.66

Table 18 - Ideal LIMS for Respondents with In-House Systems

- Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case
- The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.
- When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes
- The LIMS supports Pre-Logging by integrating with Agency Evidence Management Systems for initial data input
- The LIMS provides a high level of Data Entry automation

External Vendors. The sorted preferences based on importance for respondents with systems from commercial vendors are summarized in Table 19. The results of the analysis shows that for respondents with in-house systems *Management and Analyst Report Preparation, Daughter evidence, Chain of*

Custody Transfer, System Command Navigation, and Screen Manipulation are the five most important LIMS features. Alternatively, *Personnel Certification Management, Analyst Assignment, Asset Management, Terminal Mobility, and Interface with analytical equipment* are the least important LIMS features or capabilities for this group. Based on the utilities and the most important attributes, an ideal system for respondents with LIMS from external vendors would include the features shown in Table 20.

Table 19 - Importance for Respondents with Systems from External Vendors

	Total
Management and Analyst Report Preparation	8.74
Daughter evidence	8.07
Chain of Custody Transfer	7.87
System Command Navigation	6.55
Screen Manipulation	5.98
Data Entry	5.94
Generation of Analyst Summary Statistics	5.90
Case Prioritization	5.68
Case Evidence Status	5.67
Pre-logging	5.53
Case Grouping	5.17
Query Access to Management Data	4.79
Court system status	4.62
Interface with analytical equipment	4.52
Terminal Mobility	4.02
Asset Management	3.79
Analyst Assignment	3.61
Personnel Certification Management	3.56

Table 20 - Ideal LIMS Systems for Respondents with Systems from External Vendors

- When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes
- Supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation
- Daughter Evidence items can be created as a new piece of evidence in a case with clear links to parent evidence items and the case
- The LIMS allows analysts to create or access Summary Statistics showing performance, backlog, and other case information
- The LIMS supports Case Prioritization using several criteria

IMPLICATIONS OF ANALYSIS

Based upon interviews with multiple Midwest crime laboratories and over 90 respondents to the extensive online survey made available through this research, the most important broad factor of concern in a LIMS is the ability to *track daughter evidence*. This factor was trailed by *management and analyst report preparation*, and then *chain of custody transfer*. The factors that respondents felt offered the least utility in a LIMS were *personnel certification management*, *asset management*, and *analyst assignment*. The relative levels of importance of the factors across all levels are shown below.

	Tot	Small	Med	Large	Tech	Anlyst	Mgmt	In-House	Vend
Daughter evidence	1	1	2	1	1	2	3	1	2
Mgmt and Analyst Rpt Prep	2	3	1	3	3	1	1	2	1
Chain of Custody Transfer	3	2	3	2	2	3	2	3	3
System Command Navigation	4	6	4	6	6	4	5	6	4
Gen of Analyst Sum Stats	5	4	5	4	7	6	10	7	9
Pre-logging	6	12	8	7	4	5	9	4	7
Data Entry	7	13	7	5	12	7	11	5	5
Case Prioritization	8	5	9	11	5	8	7	11	8
Screen Manipulation	9	8	10	10	13	11	8	8	10
Case Evidence Status	10	11	6	16	9	10	4	12	6
Court system status	11	7	12	8	8	9	18	13	12
Case Grouping	12	9	14	9	16	12	14	9	13
Query Accss to Mgmnt Data	13	15	11	12	11	13	12	10	11
Interface with analytical equip	14	16	13	13	14	14	16	16	14
Terminal Mobility	15	10	15	15	17	15	15	14	15
Analyst Assignment	16	14	17	14	15	16	13	15	17
Asset Management	17	18	16	18	10	17	17	17	16
Personnel Cert Mgmnt	18	17	18	17	18	18	6	18	18

The ascribed importance of the LIMS being able to handle daughter evidence denotes that the majority of LIMS users believe the system should not

lose sight of its initial and primary function – evidence tracking. While this statement might seem obvious, it should be noted that often when priorities are not clearly outlined, it is possible to begin to move away from the core functionalities that form the foundation of the system. This point may be illustrated by the second most important feature desired in a LIMS – management and analyst report preparation. It was very interesting to see that many LIMS make reporting a very cumbersome process and, consequently, not satisfactory. This point is especially salient when the very nature of information management systems is taken into consideration. Their original – and arguably most important – function was to aggregate information into meaningful reports. This apparently has ceased to be the case for LIMS, and should therefore be re-addressed.

It is interesting to view all levels of preference in relation to each other. For example, the top three factors, *daughter evidence, management and analyst report preparation,* and *chain of custody transfer* may switch positions across all sizes of labs, position of personnel, and in-house or vendor, but they remain in one of those top three slots. Clearly, they are viewed by all as the most important factors of a LIMS. This cannot be said of the least important. Personnel certification management was either the least important or second to least for all groups except management, who placed it in the top 1/3 or desirable factors. Technicians ranked asset management tenth where all other groups kept it within the bottom three. Other relative factor rankings that are interesting are the disparity between laboratories already using a vendor product and the

other groups. While the top and bottom three are aligned with the other groups, the factors in between are moderately different. Is this due to the features to which they are already accustomed? For example, those labs using a vendor based LIMS place case evidence status in the top third of factor preference, where those who have in-house systems place it in the bottom third. Is this because the vendor based system has that feature in place and users have become accustomed to it, whereas those with in-house systems have not?

A lab may want to use the prioritization of factors to as a checklist to determine if their current LIMS or potential future LIMS provides commonly desired features. For example, taking the top ten factors from this study (listed in order of preference): daughter evidence, management and analyst report preparation, chain of custody transfer, generation of analyst summary statistics, system command navigation, pre-logging, data entry, case evidence status, screen manipulation, and case prioritization, the features may be grouped into four areas: reports and statistics, user interface, evidence tracking, and case tracking/prioritization. Current LIMS implementations may address these functional areas to some degree, but knowing specifically what sub-areas and corresponding components are important allows for better assessment of the end-to-end system. Moreover, it allows for a more explicit discussion of needs of the LIMS, whether for in-house development staff, or commercial LIMS vendors.

While the results presented in this research reflect the levels of desired factors in LIMS across Midwest forensics labs, they do not necessarily accurately represent the individual laboratory. Conversely, the results presented here are

aggregated across labs of varying sizes and potential needs. However, this report provides tremendous progress in explicitly representing the whole range of factors of concern present within any LIMS. Moreover, with the data presented in this report along with the methodology used for collecting and analyzing them, individual labs may use the results discussed herein to further clarify their own specific needs and priorities.

Interestingly, the factors that respondents indicated provide the least amount of utility are those dealing with managerial aspects of the laboratory. While individual scientists and technicians benefit from certification management, the management of laboratory equipment, and the mobility of workstations, it is usually the management personnel in a laboratory that must actively resolve issues related to each of these factors. As the majority of respondents to the survey are bench scientists or technicians, the impact that laboratory management may otherwise have with respect to featureset selection within LIMS is diminished. Therefore, it is not unexpected that these managerial factors would be identified as adding less utility than factors which directly facilitate scientific processes. This should be viewed as an artifact of the sample target and not necessarily indicative of the value such factors truly provide to any individual laboratory. However, it is worth noting that the need for this functionality may be lost on the bench scientist or technician. Thus, with all software application decisions such as the selection of a LIMS package, the final selection should incorporate input from *all* users or potential users, with the final decision resting on the shoulders of knowledgeable management personnel who

have insight into laboratory-wide issues and requirements. In the final analysis, these systems are designed to *facilitate* managerial activities rather than to act as a proxy for competent, professional, and visionary management. Therefore, while all stakeholder contributions should be considered, the final decision must rest with the management team, as input ought to be integrated into the omnibus model and result in decisions that work to refine and improve the laboratory as a whole.

REFERENCES

Akaah, I.P. & Korgaonkar, P.K. (1983). An empirical comparison of the predictive validity of self-explicated, Huber-hybrid, traditional conjoint, and hybrid conjoint models. Journal of Marketing Research (20), pp. 187-197.

Akaah, I.P. (1991). Predictive performance of self-explicated, traditional conjoint, and hybrid conjoint models under alternative data collection modes. Journal of the Academy of Marketing Science, 19 (4), pp. 309-314.

Agarwal, M.K. & Green, P.E. (1991). Adaptive conjoint analysis versus self-explicated models: Some empirical results. International Journal of Research in Marketing (8), pp. 141-146.

Bishop, M. Computer Security: Art & Science (sixth printing, Nov. 2004). Boston, MA: Addison-Wesley Professional, 2002.

Cattin, P. & Wittink, D. R. (1982). Commercial Use of Conjoint Analysis: A Survey. Journal of Marketing (46), pp. 44-53.

Enger, N.L. Classical and structured systems life cycle phases and documentation. In System Analysis and Design: A Foundation for the 1980's, W.M. Cotterman, J.D. Couger, N.L. Enger, and F. Harold, Eds. Elsevier, North Holland, 1982, pp. 1-24.

EPA Manual 2185 – Good Automated Laboratory Practices, 1995 Edition. Retrieved 28 September, 2005 from http://www.epa.gov/irmpoli8/pdfs/2185galp.pdf

Green, P. E. & A. Krieger (1991). Product Design Strategies for Target-Market Positioning. Journal of Product Innovation Management (8), pp. 189-202.

Green, P. E., Krieger, A. M., & Agarwal, M. K. (1991). Adaptive Conjoint Analysis: Some Caveats and Suggestions. Journal of Marketing Research (28), pp. 215-222.

Hauser, J.R. & P. Simmie (1981). Profit Maximizing Perceptual Positions: An Integrated Theory for the Selection of Product Features and Price. Management Science (27:2) (January), pp. 33-56.

Huber, J. (1987). Conjoint analysis: How we got here and where we are. In *Proceedings of the Sawtooth Conference on Perceptual Mapping, Conjoint Analysis and Computer Interviewing*. M. Metegrano, ed., Ketchum, Idaho: Sawtooth Software, pp. 2-6.

ISO 17025. Retrieved 28 September, 2005, from http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=39883&ICS1=3&ICS2=120&ICS3=20&scopelist=

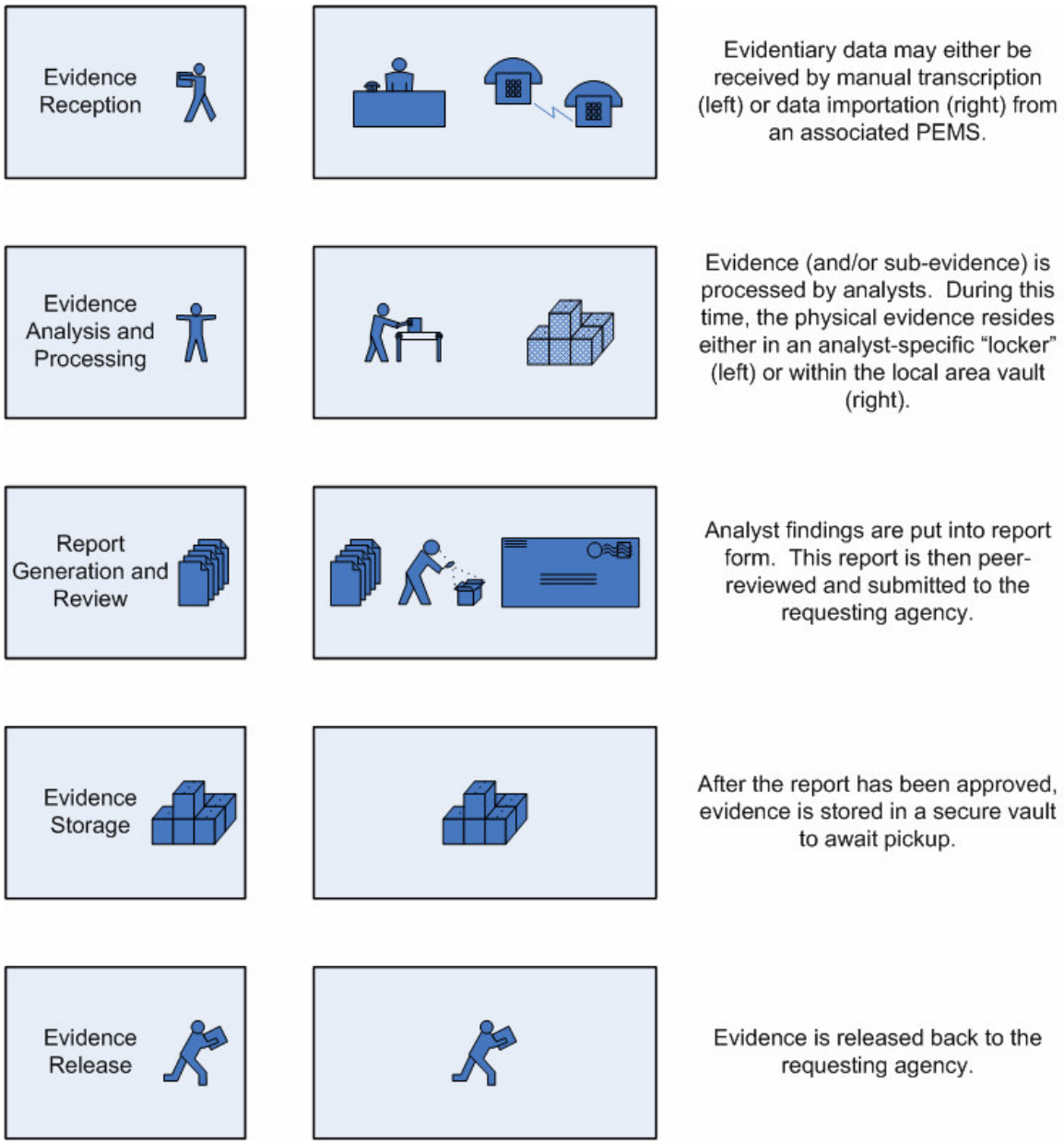
ISO 17025 (Guide 25) Home Page. Retrieved 28 September, 2005, from http://www.fasor.com/iso25/

ISO 9000 and ISO 14000. Retrieved 28 September, 2005, from http://www.iso.org/iso/en/iso9000-14000/index.html

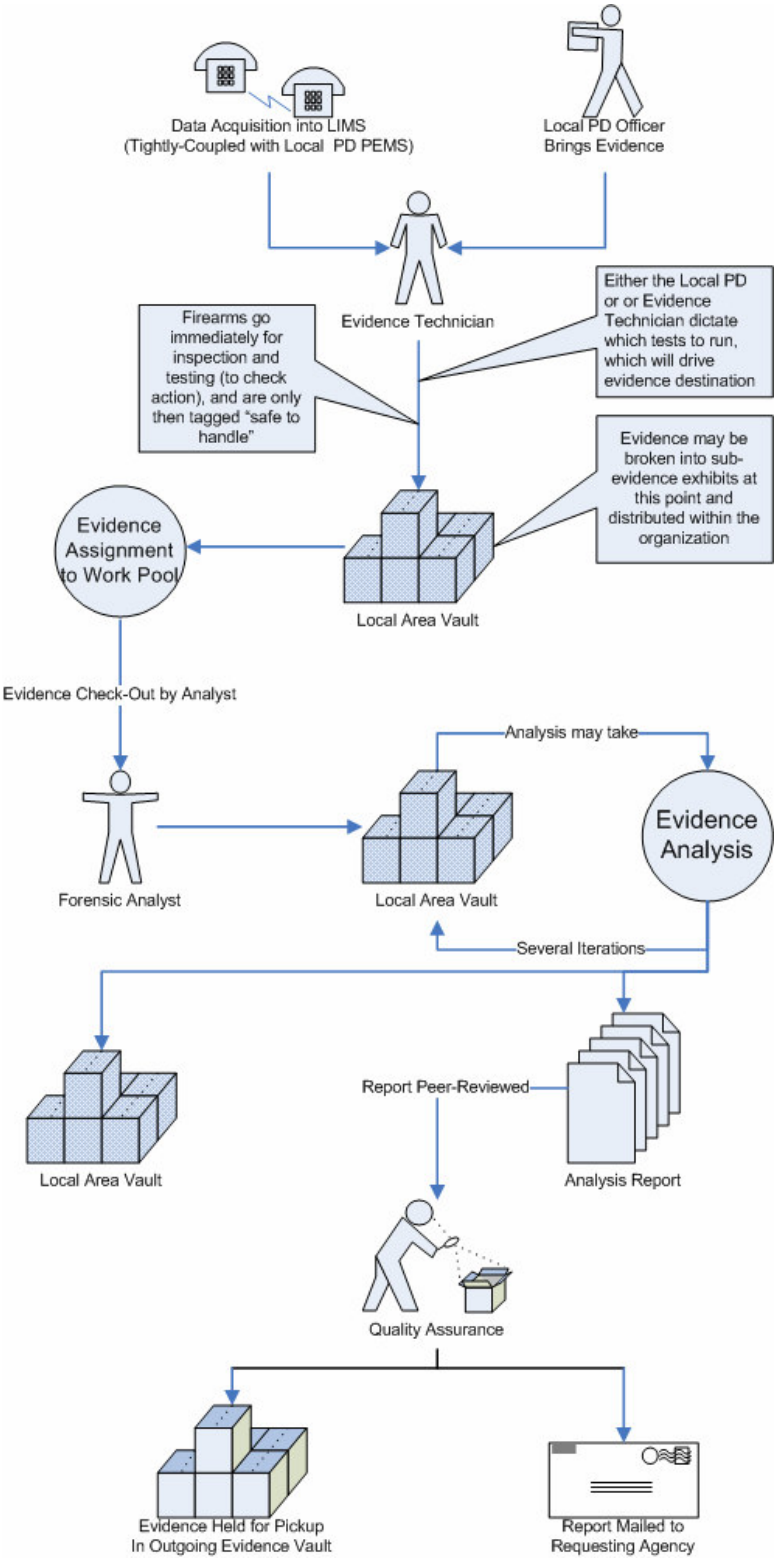
Johnson, R. (1987). Adaptive Conjoint Analysis. In Sawtooth Software Conference on Perceptual Mapping, Conjoiunt Analysis, and Computer Interviewing. Ketchum, ID: Sawtooth Software, pp. 253-265.

Johnson, R. (1991). Comment on `Adaptive Conjoint Analysis: Some Caveats and Suggestions. Journal of Marketing Research (28) (May), pp. 223-225.
Laudon, K. C. & Laudon, J. P. Management Information Systems: New Approaches to Organization & Technology. Prentice Hall, New Jersey, 1998, pp. 153.
Mahajan, V. & J. Wind (1992). New Product Models: Practice, Shortcomings and Desired Improvements. Journal of Product Innovation Management (9), pp. 128-139.
Moore, W. L., J. J. Louviere, & R. Verma (1999). Using Conjoint Analysis to Help Design Product Platforms. Journal of Product Innovation Management (16), pp. 27-39.
Orme, B. (1999). ACA, CBC, of Both?: Effective Strategies for Conjoint Research. Working Paper, Sawtooth Software, Sequim, WA.
Orme, B. (2002). Interpreting Conjoint Analysis Data, Sawtooth Software Research Paper Series, Available from http://www.sawtoothsoftware.com/download/techpap/interpca.pdf. (accessed 9/23/05)
Page, A. L. & H. F. Rosenbaum (1987). Redesigning Product Lines with Conjoint Analysis: How Sunbeam Does It. Journal of Product Innovation Management (4), 120-137.
Sawtooth Software (2002). ACA 5.0 Technical Paper. Available from http://www.sawtoothsoftware.com/download/techpap/acatech.pdf (accessed 9/21/05).
Sawtooth Software, Inc. (2005a). CBC - Choice-Based Conjoint. http://www.sawtoothsoftware.com/cbc.shtml (accessed 9/21/05).
Sawtooth Software, Inc. (2005b). CVA - Conjoint Value Analysis. http://www.sawtoothsoftware.com/cva.shtml (accessed 9/21/05).
Tumbush, J.J. (1991). Validating adaptive conjoint analysis (ACA) versus standard concept testing. In *Sawtooth Software Conference Proceedings*, M. Metegrano, ed. Ketchum, Idaho: Sawtooth Software, pp. 177-184.
Urban, G. L., B. Weinberg, & J.R. Hauser (1996). Pre-market Forecasting of Really-New Products. Journal of Marketing (60:1), (January), pp. 47-60.
Wind, J., P. E. Green, D. Shifflet, & M. Scarbrough (1989). Courtyard by Marriott: Designing a Hotel Facility with Consumer-Based Marketing Models. Interfaces, pp. 25-47.
Wittink D. R., Vriens M., & Burhenne W. (1994). Commercial Use of Conjoint Analysis in Europe: Results and Critical Reflections. International Journal of Research in Marketing (11), pp. 41-52.

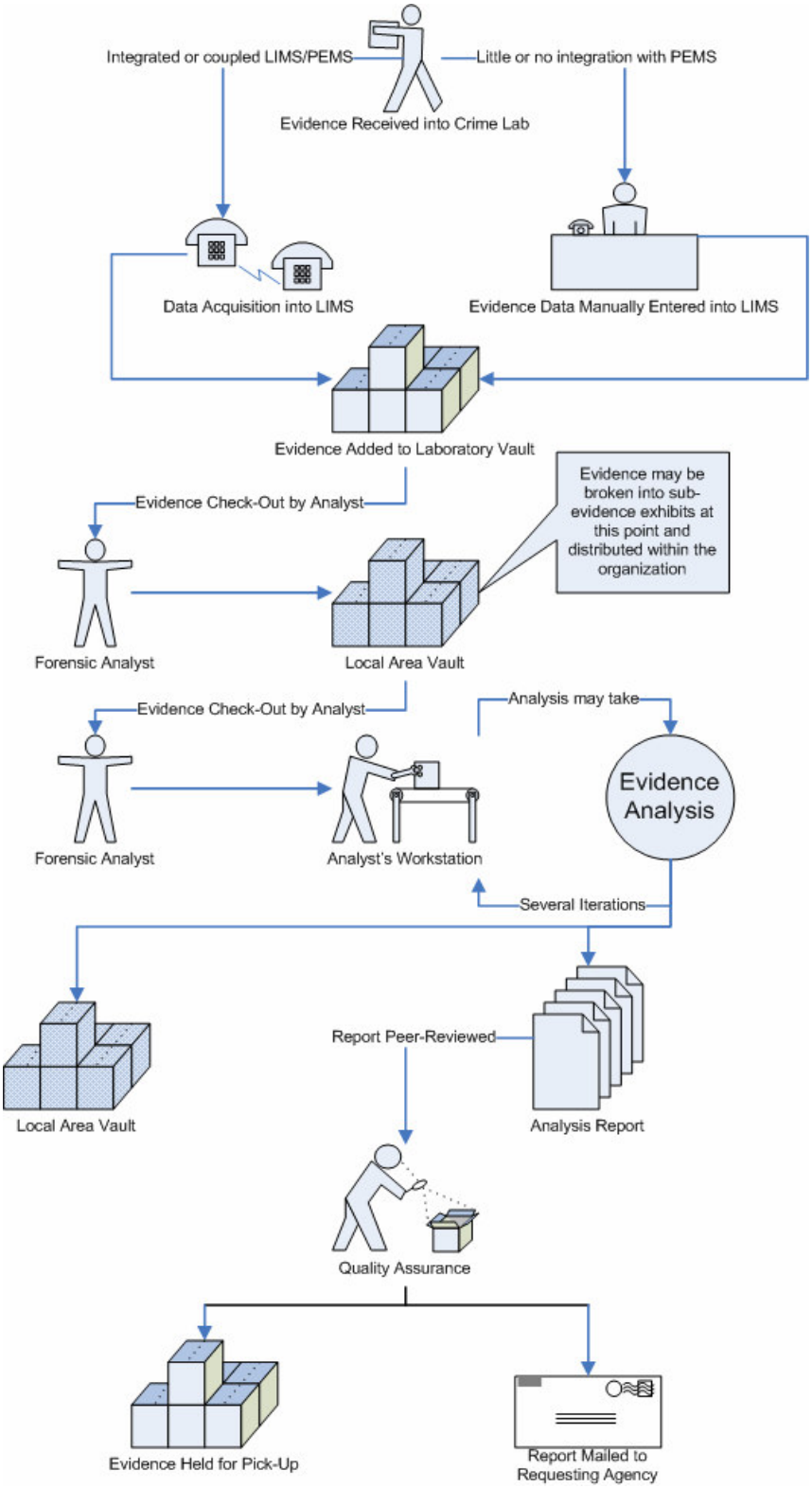
APPENDIX A – GENERIC LABORATORY PROCESS FLOW



APPENDIX B – "TIGHTLY-COUPLED" LABORATORY PROCESS FLOW



APPENDIX C – "LOOSELY-COUPLED" LABORATORY PROCESS FLOW



APPENDIX D – LIMS PROVIDERS

A matrix of vendors and product characteristics for the forensic LIMS investigated appears below. Information was primarily gathered from vendor websites and, on occasion, vendor-provided literature. Significant features that were either unique to a certain product, or not present within other LIMS implementations are recorded in the Notes section.

The operating environments in which many LIMS products are used are complex, and this complexity naturally guides software development decisions. In accordance with this, many LIMS vendors offer products comprised of a monolithic “core” surrounded by optional modules, and some vendors offer modularization of the entire product. As such, a category is present in the following tables to indicate which (if any) of these descriptions apply. Country-specific government standards can apply to software used in laboratories, and many vendor websites stated that their software either was compliant or could help a lab meet such a standard.

Server and client platforms were documented. Most vendor websites specified specific database software needed for operation. Web access appears as a common feature, and a few LIMS were accessible via a web interface only. Another feature documented was the ability of the LIMS to integrate with Microsoft Office for reporting, as well as document and image handling.

Several documented product characteristics had to do with computer security, including the security model utilized, availability of biometric integration, and usage of electronic signatures. Other product literature was more specific to

the needs of a LIMS used in a forensic laboratory context, such as bar code tracking and generation, laboratory management (thus dictating single-laboratory use capability only versus multi-lab operation), and case data management and package data management. Whether cases could be archived was also documented. Other forensic-specific features included automated instrument data collection and instrument interfacing (including physical connections supported when specified). Where given, equipment maintenance, including calibration, is reported.

Ability of any given LIMS to carry out analysis requests is reported as a simple *yes* or *no*. The ability of a system to generate worksheets and reports were each given more detail, including format and whether reports were "hyperlinked" (i.e. the user is able to click on text in the document and access more detailed information about that object), and whether such reports could be distributed using email or fax. The ability of the system to manage the laboratory's inventory of consumables was recorded, as well as the related feature of "Supply Ordering". In forensics laboratories, physical storage and warehousing of samples comes with the territory; some LIMS have the ability to store and display this location, and this too is displayed in the tables below.

As these are key features of a LIMS, audit trail and chain of custody are reported, along with the ability of a LIMS to support both quality assurance (QA) and quality control (QC). Below, "People Management" refers mostly to employee scheduling, and "Training Management" describes the ability of the LIMS to warehouse specific certifications held by employees.

Graphics and visualization appear in the following tables in the context of their use within statistical analysis. Billing and quoting often was a feature that integrated with an accounting package. Finally, customer support was documented, and consists primarily of contact information.

Product Name	**CaseMan**
Manufacturer	Promadis
Notes	From an Australia-based vendor, CaseMan is a complete and robust system with a focus on distribution tools. Principal Areas of Operations are: Main Case Management, Blood Alcohol DNA, Chemistry, Administration Reports, Biology Reports, Management Reports, Ad-hoc Reports, Jobs Query, System Functions
Modules	Main areas of operations are standard, however many optional essential modules are available (Optional)
Standards Compliancy	NATA- National Association Testing Authorities, Australia
Client Platforms	Windows
Server Platform(s)	Windows: Microsoft Windows NT and 2000 Server Unix: IBM AIX on the powerful RISC 6000 hardware, HP Unix and SCO Unixware on scalable Intel platforms Linux: Red Hat Linux
Database	Support most native databases management systems, like Oracle and SQL Server. It also supports ODBC, OLTP, OLAP, Crystal Reports, and RPC
Web Access	Not Specified
MS Office Integration	Not Specified
Security Model	Not Specified
Biometric Integration	No
Electronic Signatures	No
Bar Code Tracking/ Generation	Yes, Bar-Coding is supported as a tool of data collecting.
Lab Management	Yes
Case Data Management	Yes, Contains a comprehensive case management and reporting system, which integrates with police systems
Package/Item Management	Not Specified
Automated Instrument Data Management	Not Specified
Instrument Interfacing	Not Specified
Document/ Image Handling	Yes, as part of the Case Management application, photos, documents and file can be associated with cases, exhibits and samples. It contains a digital camera interface that allows the connection of a digital camera for easy uploading of images.
Analysis Request Mgmt.	
Worksheet Generation	Yes, no format given
Report Generation	Yes, Different formats of reports available. Reports distribution via encrypted email and fax.
Inventory Management	
Audit Trail	Yes
Chain of Custody	
QA/QC Management	Yes
People Management	Not Specified
Case Archive	Yes, Electronic format is supported
Storage Location Management	No
Supply Ordering	No
Training Management	Not Specified
Statistical Analysis	Not Specifics on Capabilities
Visualization (Graphics)	Yes
Billing / Quoting	Not Specified
Equipment Maintenance	Yes
Customer Support	Telephone: (08) 8357 8040 Facsimile: (08) 8357 8860 Email: info@promadis.com

Product Name	**RLIMS-Forensics**
Manufacturer	RJ Lee Solutions
Notes	An ideal software for small to medium size laboratories, it offers a focus in customized software solutions, requirements definition and planning, system design and implementation, data migration, and interfacing to laboratories instruments
Modules	Not specify any modules
Standards Compliancy	
Client Platforms	Not Given
Server Platform(s)	
Database	
Web Access	
MS Office Integration	
Security Model	
Biometric Integration	
Electronic Signatures	
Bar Code Tracking/ Generation	
Lab Management	
Case Data Management	Yes, Secure Case Management. A module called Evidence Management available, which stores data from each sample.
Package/Item Management	
Automated Instrument Data Management	
Instrument Interfacing	
Document/ Image Handling	
Analysis Request Mgmt.	
Worksheet Generation	
Report Generation	Yes
Inventory Management	Yes
Audit Trail	Yes
Chain of Custody	
QA/QC Management	
People Management	
Case Archive	
Storage Location Management	
Supply Ordering	
Training Management	
Statistical Analysis	
Visualization (Graphics)	
Billing / Quoting	
Equipment Maintenance	
Customer Support	Jill Johnston 3311 West Clearwater Ave. Ste. 16 Kennewick, Washington 99336 Telephone: 1-866-843-0834 Fax: 1-509-735-1002 Email: infolims@rjls.com

Product Name	**RLIMS-Pro**
Manufacturer	RJ Lee Solutions
Notes	A companion product to RLIMS Forensic, is a Window-based version of the relational laboratory information management system (RLIMS) model developed by the US Environmental Protection Agency.
Modules	It consists of one main module with the options of some extra customized modules
Standards Compliancy	ISO 9000 Standards
Client Platforms	Windows
Server Platform(s)	Not really clear, but given the fact that is a Window-based system, Windows Server System as well as SQL Server and Oracle, should be supported
Database	Oracle
Web Access	Not Specified
MS Office Integration	Yes
Security Model	5 Level of Access Privileges, password protected
Biometric Integration	No
Electronic Signatures	No
Bar Code Tracking/ Generation	Not Specified
Lab Management	Yes, Supports different lab environments
Case Data Management	Not Specified
Package/Item Management	Not Specified
Automated Instrument Data Management	Yes, but details on specific lab instruments
Instrument Interfacing	Provides three levels of approval for instrument run: Chemist, Peer Review, Final QA/QC
Document/ Image Handling	Not Specified
Analysis Request Mgmt.	No
Worksheet Generation	No
Report Generation	Yes, Custom and Standard Reports including a general management report and ad hoc queries and reports
Inventory Management	Yes
Audit Trail	Not Specified
Chain of Custody	Not specific but states that it initiate and maintain chain of custody
QA/QC Management	Yes, control chart display
People Management	Yes, it supports personnel scheduling as well as instrument usage schedules
Case Archive	Yes, archives by date, project, instrument, sample, batch, instrument run
Storage Location Management	Not Specified
Supply Ordering	No
Training Management	Not Specified
Statistical Analysis	Not Specified
Visualization (Graphics)	Yes
Billing / Quoting	Yes, but not specific on which accounting packages can be integrated to
Equipment Maintenance	Yes, not specific if calibration is included
Customer Support	Jill Johnston 3311 West Clearwater Ave. Ste. 16 Kennewick, Washington 99336 Telephone: 1-866-843-0834 Fax: 1-509-735-1002 Email: infolims@rjls.com

Product Name	**B.A.R.D.**
Manufacturer	Forensic Technology, Inc.
Notes	Stands for “Beyond A Reasonable Doubt”. It is actually a software suite which incorporates a LIMS solution
Modules	LIMS(available), ERP (Available), Data Management (Available)
Standards Compliancy	ASCLD/LAB, ISO 17025
Client Platforms	Windows
Server Platform(s)	Windows
Database	Oracle, capability to use ADO/ODBC DB's
Web Access	Secure web access integrated, not required for use
MS Office Integration	generate/create
Security Model	role-based
Biometric Integration	Yes
Electronic Signatures	Yes
Bar Code Tracking/ Generation	Software only
Lab Management	Single lab only
Case Data Management	By Case
Package/Item Management	support for sub-items and split-items
Automated Instrument Data Management	Supported, no instruments listed
Instrument Interfacing	Not Given
Document/ Image Handling	Yes, formats not supplied
Analysis Request Mgmt.	
Worksheet Generation	Yes
Report Generation	Yes, for analytical and statistical reporting. Formats not given
Inventory Management	Yes
Audit Trail	Yes
Chain of Custody	Yes
QA/QC Management	Yes
People Management	Yes
Case Archive	Yes, Electronic/Database driven
Storage Location Management	Yes, via ERP module
Supply Ordering	No
Training Management	No
Statistical Analysis	Yes, Not specified
Visualization (Graphics)	No
Billing / Quoting	No
Equipment Maintenance	No
Customer Support	5757 Cavendish Boulevard, Suite 200 Montreal, Quebec, Canada H4W 2W8 Telephone: +1 514-489-4247 Canada/USA Toll free +1-888-984-4247 Fax: +1 514-485-9336 fti@fti-ibis.com. Training services are also available.

Product Name	CrimeFighter Beast
Manufacturer	Porter Lee Corporation
Notes	Sales materials read more like user manual than sales documents
Modules	
Standards Compliancy	
Client Platforms	Win98+, requires 2 DB9 Ports
Server Platform(s)	WinNT SP6+, requires 2 DB9 Ports
Database	Not Specified, screen shots + report samples suggest MS Access
Web Access	Yes, not required to function
MS Office Integration	Generate/Create Template, Wizards
Security Model	Other, listed as "customizable".
Biometric Integration	
Electronic Signatures	No
Bar Code Tracking/ Generation	Yes, software only. Mention made to included bar-code labels
Lab Management	Single lab only
Case Data Management	By Case
Package/Item Management	Yes, via integrated Police Property Inventory System
Automated Instrument Data Management	No
Instrument Interfacing	Yes, Not given but requirements for DB9 Ports allude to RS-232
Document/ Image Handling	Yes formats not supplied
Analysis Request Mgmt.	No
Worksheet Generation	No
Report Generation	Yes. On Screen Display. Non hyperlinked
Inventory Management	Yes
Audit Trail	No
Chain of Custody	Yes
QA/QC Management	Yes
People Management	No
Case Archive	No
Storage Location Management	Yes
Supply Ordering	Yes
Training Management	Yes
Statistical Analysis	Backlog, TurnAround, Submission Types. All with various reporting scopes
Visualization (Graphics)	Integrated graphs in reports
Billing / Quoting	Yes, internal
Equipment Maintenance	Yes
Customer Support	support@porterlee.com. No mention made of post-sales support or training. Corporate HQ Phone: (847)985.2060.

Product Name	**Forensic Lims**
Manufacturer	Management Systems Designers, Inc.
Notes	
Modules	Case Management, Evidence Tracking, General Services, optional modules can be tailored to individual lab needs. Examples include Chemistry, Physical Evidence, Fingerprinting, Case Profiling, and Imaging.
Standards Compliancy	
Client Platforms	Web-Based
Server Platform(s)	Not Specified
Database	Not Specified
Web Access	Required, full access needed for operation
MS Office Integration	No
Security Model	password, user-based
Biometric Integration	No
Electronic Signatures	No
Bar Code Tracking/ Generation	Software only
Lab Management	
Case Data Management	By Case
Package/Item Management	Item. Via Barcode
Automated Instrument Data Management	No
Instrument Interfacing	No
Document/ Image Handling	No
Analysis Request Mgmt.	No
Worksheet Generation	No
Report Generation	Yes, via templates.
Inventory Management	No
Audit Trail	Yes
Chain of Custody	Yes
QA/QC Management	No
People Management	No
Case Archive	No
Storage Location Management	No
Supply Ordering	No
Training Management	No
Statistical Analysis	No
Visualization (Graphics)	No
Billing / Quoting	No
Equipment Maintenance	No
Customer Support	No specific support e-mail given. Info@msdinc for general inquiries. Corporate phone # (703) 891-6401

Product Name	**LIMS-Plus**
Manufacturer	JusticeTrax
Notes	Offers "rapid case entry" : minimal data required to assign permanent lab case #; "Cascading Services" prompts current criminalist to determine whether a secondary activity is required (e.g., just finished a controlled substances exam, do a latent print exam now?)
Modules	analytical modules: Blood alcohol, Controlled Substances, Firearms, Serology, Toxicology. Optional CIMM is Chemical Inventory Management Module
Standards Compliancy	"most labs using LIM-plus are ASCLD-LAB accredited"
Client Platforms	not specified; they offer support for Windows at fees above maintenance agreement
Server Platform(s)	
Database	ODBC
Web Access	iPreLog allows evidence submission forms to be prepared and sent to the lab prior to evidence submission; iResults allows agencies to download reports
MS Office Integration	implied -- "Word templates"
Security Model	role-based
Biometric Integration	
Electronic Signatures	
Bar Code Tracking/ Generation	yes; they offer a full line of bar code printers and scanners
Lab Management	yes; evidence can easily undergo interlab transfers, staff can view casework at other labs
Case Data Management	anything can be added to cases
Package/Item Management	Hierarchical evidence structures of unlimited generations; "evidence containers" supported.
Automated Instrument Data Management	Batch processing of all services available: scan 1 barcode, everything for work list can be updated.
Instrument Interfacing	interfaces with Any TWAIN compliant device to associate images with a case; mentions integration with analytical instruments, including graphical output.
Document/ Image Handling	Images can be annotated and rubberstamped, basic processing, comparison within the LIMS.
Analysis Request Mgmt.	iPreLog
Worksheet Generation	
Report Generation	"uses industry standard reporting tools" for complex or graphical reports. Comes with built-in system reports and allows you to build your own. Specifically mentions management statistics.
Inventory Management	for chemicals, optional through CIMM; RECON module allows a PalmOS with integrated barcode scanner to securely communicate with LIMS.
Audit Trail	"field-level auditing"
Chain of Custody	handled through bar codes. Has auto-logoff. "z-order": each barcode-scan/PIN process requires current and target location ensuring two-sided transfer
QA/QC Management	Event notification system for review process; can be used in conjunction with assignment processes
People Management	
Case Archive	
Storage Location Management	
Supply Ordering	
Training Management	
Statistical Analysis	
Visualization (Graphics)	

Product Name	**LIMS-Plus**
Billing / Quoting	integrates with Crystal Reports
Equipment Maintenance	
Customer Support	Yearly Maintenance agreement covers support and upgrades; zero hold time; web-based support/meeting center; online knowledgebase; ftp access to handbooks, etc. One West Main Mesa, AZ 85201 480.222.8900 1-800-288-5467 support@justicetrax.com

Product Name	**LabLynx LIMS**
Manufacturer	LabLynx
Notes	emphasizes customization a great deal
Modules	Sample Logging - Sample Tracking - Test Results Entry - Batching - Invoicing - Inventory Management - Collaboration - Sales & Customer Service - and many others
Standards Compliancy	The LABLynx ELab is fully compliant with 21 CFR 11, including validated digital signatures, a complete audit trail, versioning, and system time-out.
Client Platforms	Internet Explorer -- one aspect of customization is the level of client-side processing
Server Platform(s)	Windows 2000 server running IIS, recommends dual server (one for DB, one for application -- db server can run Linux)
Database	ODBC
Web Access	Uses ASP and DHTML; appears to be for clients to log in samples pre-submission. Web server is necessary but the network does not have to be connected to the greater Internet.
MS Office Integration	implied to be interoperable -- says you can "access the LABLynx database" from excel, access, or word; this access can be restricted for security purposes. Can export to Excel. Can also import ASCII text files
Security Model	role/group-based
Biometric Integration	
Electronic Signatures	During user set-up in the LABLynx Security module, authorized users can upload an image of the user's digital signature, and store it in the system. The image can be printed with the reports where necessary. The system will require a password from the user to apply their signature to the report.
Bar Code Tracking/ Generation	Bar coding capabilities that support most bar code vendors, models and symbologies (recommends Zebra)
Lab Management	scalable; has global option
Case Data Management	"track status by batch, project or sample
Package/Item Management	track samples and assign disposal dates based on user defined information
Automated Instrument Data Management	allows batch log in of samples; maintenance and calibration scheduling=separate module
Instrument Interfacing	yes -- supports EDD
Document/ Image Handling	Documents handled include regulations, methods, SOPs, permits, certifications - users upload to the web server. Has versioning (CFR part 11 requirement)
Analysis Request Mgmt.	Client can log in samples pre-submission via web
Worksheet Generation	

Product Name	**LabLynx LIMS**
Report Generation	Excel, Crystal Reports, Word, Access, HTML. Included reports: (can create new ones or modify these)¨ Certificate of Analysis ¨ Report of Analysis ¨ Report of Analysis with QC ¨ Report of Analysis Draft ¨ Amended Report of Analysis ¨ Project Report ¨ Audit trail reports ¨ Chain of custody reports ¨ Management reports ¨ Statistical Reports ¨ On-the-fly reports ¨ Control Charts Has email and fax integration (winfax Pro softare required)
Inventory Management	yes -- inventory items can be made up of other items (e.g., reagents); upper and lower control limits
Audit Trail	yes (CFR-11)
Chain of Custody	tells you when a sample was checked in or out and by whom; has auto-logoff feature
QA/QC Management	customized to the lab; alerts on due dates though color coding -- is its own module, ("Control charting") handled through an excel template
People Management	Employee scheduling of repetitive/routine tasks
Case Archive	
Storage Location Management	
Supply Ordering	Bottle order function
Training Management	certifications managed (separate module)
Statistical Analysis	
Visualization (Graphics)	
Billing / Quoting	integrated quoting system; can integrate with most accounting software for invoicing (quoting one separate module, accounting is another)
Equipment Maintenance	
Customer Support	Sales & Marketing: Ron McNutt (713)263-0900 rmcnutt@LABLynx.com LABLynx, Inc 1770 The Exchange Suite 240 Atlanta, GA 30339 Voice: 770-859-1992 or 866-LAB-LYNX (522-5969) Fax: 209-844-3664 Web Site: http://www.lablynx.com Sales E-mail: sales@lablynx.com

Product Name	**StarLIMS**
Manufacturer	StarLIMS
Notes	Web Service approach taken. Uses Crystal Reports internally.
Modules	TONS. Pluggable architecture.
Standards Compliancy	FDA (21 CFR Part 11), EPA, NELAC, OSHA, ASCLD, ISO and GaLP
Client Platforms	Any with a supported web browser (through "Web Services")
Server Platform(s)	Not given.
Database	Pluggable
Web Access	Yes
MS Office Integration	Interoperable - MS suite
Security Model	Pluggable (e.g. web protection)
Biometric Integration	No
Electronic Signatures	yes
Bar Code Tracking/ Generation	yes
Lab Management	No - although it likely COULD be used as such.
Case Data Management	Yes; query-able
Package/Item Management	Yes; "sample". Document management is a part of the system, too.
Automated Instrument Data Management	Yes; integrable with process automation systems.
Instrument Interfacing	Available, via an internal Data Capture Utility (DCU)
Document/ Image Handling	Yes; document management and exporting via XML.
Analysis Request Mgmt.	No
Worksheet Generation	Yes; entirely pluggable XML architecture.
Report Generation	Yes; entirely pluggable XML architecture.
Inventory Management	Yes; complete via an "integrated electronic record management module".
Audit Trail	Yes; FDA (21 CFR Part 11)
Chain of Custody	Yes
QA/QC Management	Yes (explicit); through console interface (QC). Yes (implicit); through analyst performance measures.
People Management	Yes; employee (analyst) workload.
Case Archive	Yes; implicit database storage.
Storage Location Management	No
Supply Ordering	No
Training Management	No
Statistical Analysis	Yes
Visualization (Graphics)	Yes; indirectly via pivot charts / XML exports (Excel)
Billing / Quoting	Yes; Great Plains financial package given as an example. However, with XML, anything ought to be possible.
Equipment Maintenance	No
Customer Support	4000 Hollywood Boulevard # 515 South Hollywood, FL 33021-6755 Tel: +1 954 964 8663 Fax: +1 954 964 8113 Full intranet for customers only.

Product Name	**StarFruit Technologies**
Manufacturer	Data Unlimited International, Inc.
Notes	2 US patents granted on LIMS products. 09/754,425 and 09/852,452
Modules	
Standards Compliancy	
Client Platforms	
Server Platform(s)	
Database	
Web Access	
MS Office Integration	
Security Model	
Biometric Integration	
Electronic Signatures	
Bar Code Tracking/ Generation	
Lab Management	
Case Data Management	
Package/Item Management	
Automated Instrument Data Management	
Instrument Interfacing	
Document/ Image Handling	
Analysis Request Mgmt.	
Worksheet Generation	
Report Generation	
Inventory Management	
Audit Trail	
Chain of Custody	
QA/QC Management	
People Management	
Case Archive	
Storage Location Management	
Supply Ordering	
Training Management	Yes
Statistical Analysis	
Visualization (Graphics)	
Billing / Quoting	
Equipment Maintenance	
Customer Support	

Product Name	**Starfruit CrimeLab**
Manufacturer	Data Unlimited International, Inc.
Notes	
Modules	Drug, Toxicology, Trace Analysis, DNA biology, Latent Print, Crime Scene, Firearm, Photography, Evidence Control, Question Documents
Standards Compliancy	Supports NFLIS extract (DEA); AFIS (Automated Fingerprint Identification System)
Client Platforms	Not given.
Server Platform(s)	Not given.
Database	Yes; Not given, but likely internal DB.
Web Access	No
MS Office Integration	No; PDF files are used instead, and signed electronically.
Security Model	Multi-Level security.
Biometric Integration	No
Electronic Signatures	Yes; used with PDF files generated from the system.
Bar Code Tracking/ Generation	Tracking; Unclear if the system can generate barcodes though.
Lab Management	Can be used to drill into multi-lab cases; searchable by defendants, victim, and complaint cases.
Case Data Management	Yes; searchable database.
Package/Item Management	Yes; via "integrated evidence management and control"
Automated Instrument Data Management	No; None given.
Instrument Interfacing	No; None given.
Document/ Image Handling	Yes; PDF files are generated for output reports (see "Report Generation). Image files of some sort have to be used for "photo service" module.
Analysis Request Mgmt.	No; not mentioned.
Worksheet Generation	No; not outside report generation.
Report Generation	ATF batch reports. PDF file generation for "all reports" (casework, ATF, etc), with page numbers and timestamps.
Inventory Management	Yes; via "Wireless inventory accounting and vault inspection"
Audit Trail	No; no clear indication of logging present.
Chain of Custody	Yes; paperless via bar codes and smart cards.
QA/QC Management	No
People Management	No, likely not (though possible that "mobile management" could perform some crude on-site employee reporting).
Case Archive	Yes; seems to store in a (proprietary?) database.
Storage Location Management	No
Supply Ordering	No
Training Management	Yes, of sorts: "Proficiency history, court testimony hours and cases and capability statement" given.
Statistical Analysis	Yes; for DNA module.
Visualization (Graphics)	Unclear; DNA module has "interpretation reports"
Billing / Quoting	No
Equipment Maintenance	No
Customer Support	Phone: 240-631-7933 Fax: 240-631-7937 Email: contact@duii.com

Product Name	Starfruit GeneTell LIMS
Manufacturer	Data Unlimited International, Inc.
Notes	Supports PCR via extraction, amplification, genotyping, gel evaluation, and enzyme digestion.
Modules	infectious organisms, genetic rearrangements (malignant disease and hereditary)
Standards Compliancy	
Client Platforms	Not given.
Server Platform(s)	Not given.
Database	Yes; Not given, but likely internal DB. It is also "user-configurable"
Web Access	No.
MS Office Integration	No.
Security Model	Not given; appears to be password-based, though.
Biometric Integration	No
Electronic Signatures	Yes, through use of smart cards.
Bar Code Tracking/ Generation	Tracking; Unclear if the system can generate barcodes though.
Lab Management	Yes; called management of "clinics, hospitals"
Case Data Management	Yes; an aggregation of "tests".
Package/Item Management	Yes, "sample". This is in a db of indeterminate format.
Automated Instrument Data Management	No
Instrument Interfacing	No
Document/ Image Handling	Yes, format unknown (text only?). Image handling n/a.
Analysis Request Mgmt.	No
Worksheet Generation	Yes, via "suggestive [sic]" reports.
Report Generation	Yes - "suggestive [sic] reports"
Inventory Management	Yes, there is a listing of "chemicals, equipment, vendors, reports"
Audit Trail	Possibly, through the administrative tool or process tool.
Chain of Custody	Yes, through check-in/check-out vault process for samples.
QA/QC Management	No
People Management	Limited; allows for creation of users/groups, but no scheduling, etc.
Case Archive	Yes, under "Laboratory Process" tool. Internal db storage.
Storage Location Management	Possibly.
Supply Ordering	No
Training Management	No
Statistical Analysis	No
Visualization (Graphics)	No
Billing / Quoting	Yes
Equipment Maintenance	Yes
Customer Support	Phone: 240-631-7933 Fax: 240-631-7937 Email: contact@duii.com

Product Name	**Starfruit IdentiTrack LIMS**
Manufacturer	Data Unlimited International, Inc.
Notes	LIMS for Parentage Testing Laboratories CODIS Testing Laboratories Forensic DNA Biology Laboratories.
Modules	
Standards Compliancy	Aids in AABB, ASCLD, CAP, NFSTC compliance via an "automation permit"
Client Platforms	Not given.
Server Platform(s)	Not given.
Database	Yes; internal db.
Web Access	No.
MS Office Integration	Not listed.
Security Model	None
Biometric Integration	No
Electronic Signatures	Yes
Bar Code Tracking/ Generation	Tracking; Unclear if the system can generate barcodes though.
Lab Management	No
Case Data Management	Yes, via "Electronic Case Folders"
Package/Item Management	Yes, "sample". This is also in the "Electronic Case Folder"
Automated Instrument Data Management	Importing of allele data from instruments; automatic forensic matching.
Instrument Interfacing	Yes, but unknown port/support configuration.
Document/ Image Handling	Automatic report generation. Format unknown, likely text-only.
Analysis Request Mgmt.	No
Worksheet Generation	No; not outside report generation.
Report Generation	Yes; inclusion or exclusion paternity test results.
Inventory Management	Yes; no additional information given.
Audit Trail	No; no clear indication of logging present.
Chain of Custody	Yes; paperless via bar code. BUT, with no security, it's hard to enforce.
QA/QC Management	No
People Management	No.
Case Archive	Yes. Likely via an electronic "case folder".
Storage Location Management	No.
Supply Ordering	No
Training Management	No
Statistical Analysis	Yes; implicit.
Visualization (Graphics)	No
Billing / Quoting	No
Equipment Maintenance	No
Customer Support	Phone: 240-631-7933 Fax: 240-631-7937 Email: contact@duii.com

Product Name	**Starfruit Toxicology LIMS**
Manufacturer	Data Unlimited International, Inc.
Notes	
Modules	
Standards Compliancy	
Client Platforms	Not given.
Server Platform(s)	Not given.
Database	Yes; of indeterminate format.
Web Access	No
MS Office Integration	Export billing to EXCEL.
Security Model	group-based / RBAC
Biometric Integration	No
Electronic Signatures	Yes
Bar Code Tracking/ Generation	Yes; barcode labeling mechanism that is used for identifying/tracking samples, and also for chain of custody.
Lab Management	No
Case Data Management	No
Package/Item Management	Yes; called a "case"
Automated Instrument Data Management	No
Instrument Interfacing	No
Document/ Image Handling	Yes; "you can add digial image" [sic]
Analysis Request Mgmt.	No
Worksheet Generation	Yes; batch worksheets.
Report Generation	Printed; electronic (bound with electronic signature)
Inventory Management	Yes; "inventory control".
Audit Trail	No; no clear indication of logging present.
Chain of Custody	Electronic signature SOP; barcode LIMS; its "chain of custody letter" "meets the requirement of the crime forensic laboratories".
QA/QC Management	No
People Management	Yes; employee workload, court testimony (hours), training (hours), discovery prep (hours)
Case Archive	No
Storage Location Management	Somewhat; can be tracked via barcode scans.
Supply Ordering	No
Training Management	Via tracking of hours of training.
Statistical Analysis	No
Visualization (Graphics)	No
Billing / Quoting	Yes; likely text-only export.
Equipment Maintenance	Only through tracking hours (of use)
Customer Support	Phone: 240-631-7933 Fax: 240-631-7937 Email: contact@duii.com

Forensic LIMS':

BARD LIMS
Vendor/Abstract from http://www.limsource.com: Forensic Technology Inc.

Specifically designed for forensic laboratories. Stands for Beyond A Reasonable Doubt. Composed of 3 modules, Bard LIMS, Bard ERP for managing property and evidence, and Bard Data Management. Designed to interface with MS Office for report customization and creation.

Crime Fighter Beast
Vendor/Abstract from http://www.limsource.com: Porter Lee Corporation

Designed for law enforcement. Windows based LIMS incorporating property inventory system, digital image capture, instrument interface, lab asset management, backlog reporting, custom reports, and customizable security.

ForensicLIMS (FLIMS)
Vendor/Abstract from http://www.limsource.com: Management Systems Designers, Inc.

Forensic LIMS. Focus on case management, evidence tracking, and examination processing. Auditable chain of custody via barcodes. Modules available for various examination types such as chemistry, fingerprint analysis, physical evidence, documents. Custom modules can be created. Reports can be generated from both template and custom.

JusticeTrax LIMS-plus
Vendor/Abstract from http://www.limsource.com: JusticeTrax

Criminal Justice LIMS. Contains a complete case management interface, with predefined milestones, customized evidence kits, work lists, and pick lists. Modules to import data automatically from lab instrumentation. Bar code technology to manage chain-of-custody. Both Lab and management reports come with predefined and customizable options. Role based access security. PreLog application to allow submitting agencies to begin data input prior to arrival of samples/evidence. JusticeTrax PathAssist offers similar functionality for medical examiners and coroners.

LABLynx
Vendor/Abstract from http://www.limsource.com: LABLynx, Inc.

Custom tailored LIMS. Specific mention made of tailoring towards forensic applications. Constructed with Microsoft technology such as WinNT, IIS, MSOffice, and VBScript. Tailoring done via the addition or removal of modules. A list of current features is available here: http://www.lablynx.com/Functionality.asp. Discussion of its forensic capabilities is available here: http://www.lablynx.com/forensics.asp.

Promadis CaseMan
Vendor/Abstract from http://www.limsource.com: Promadis

Forensic Case management LIMS. Automatic information collection from analyzers, barcode integration, and associations of cases with database records. Electronic encryption for report distribution. Performance and management reporting.

RLIMS-FORENSICS
Vendor/Abstract from http://www.limsource.com: R.J.Lee Solutions

Designed specifically for forensic research labs. Includes support for the management of data related to evidence management, toxicology, blood alcohol, controlled substances, serology, firearms, trace evidence, and miscellaneous. Also, provides internal chain-of-custody control, automated data capture from instruments, automated narcotic bench sheets, supplies/inventory control and reporting, query and reporting capabilities, and secure case management.

StarFruit CrimeLab
Vendor/Abstract from http://www.limsource.com: Data Unlimited International

Forensic Crime Lab LIMS. Evidence and sample tracking via barcodes. Paperless chain of custody combining bar-coding and smart cards. Multi-level security access. Tracks proficiencies and court testimony hours. DNA analysis/interpretation support. Electronic peer review/sign-off. Electronic generation of PDF's w/ digital signature. Casework reports with time stamping. Case management of evidence. Wireless inventory accounting/vault control. Integrated evidence management/control.

StarLIMS
Vendor/Abstract from http://www.limsource.com: STARLIMS

Generic LIMS tailored to specific markets by vendor. Mention made of use in public health, pharmaceutical, petrochemical, forensics, food/beverage, environmental, and chemical markets. Can maintain chain-of-custody procedures, including audit trail, bar-coding, electronic data storage, and electronic signatures. Uses Web Services for OS interoperability.

Other LIMS Packages:

Agri-Labs Information System (ALIS)
Vendor/Abstract from http://www.limsource.com: Desertcom Oasis Software

Targeted towards the agricultural testing market. Programmed in the Clarion language for relational databases. Modular design, with modules supplied focusing on Soils, Plants, Waters, Feeds, Fertilizers, and Air. Currently in use by ISU Soil & Plant Analysis Lab. Windows Platform.

AIS LIMS
Vendor/Abstract from http://www.limsource.com: Analytical Information Systems, Ltd.

There is no specific target for this product; instead the manufacturer emphasizes its configurability. Emphasis on Analytical Quality Control. Support for data gathering interfaces via keyboard wedges. Support for report generation in R&R Report Writer, Crystal Reports, and Excel. Optional modules include Interactive Analytical Quality Control and Charting, Graphics, Stability pre-scheduling, Statistical Limit Checking, Invoice Generation, Fax & Email servers, Stock control, Instrument calibration management, and water inspection reports. Can run on a stand alone workstation, but recommends client server architecture utilizing SQL Server or Extended Systems Advantage.

Analisi
Vendor/Abstract from http://www.limsource.com: Polisystem Informatica S.r.l.

English port of an Italian language LIMS. Modular design. Standard module load includes support for sample reception, general sampling, work lists, laboratory logging, defining access control for each field and menu option, statistics/graphing, and outputting test reports. Optional modules add support for automated sample planning, data capture from notebook or Pocket PC devices, invoicing, integration of Laboratory Service Site, data sharing via the Internet, and direct data capture from connected devices. Specialized modules include Atmospheric Emissions, Wines, Waste, Material Tests, ARPA, and Manufacturing Quality Controls. Designed for use with Windows/OBDC compliant database systems.

Aspen LIMS
Vendor/Abstract from http://www.limsource.com: Telecation

Generic LIMS with documented uses in the Commercial Testing, Food & Beverage, Geochemical/Mining, Government, Health, Manufacturing/QC, and Water sectors. Two versions are available. Aspen standard ships with Access to function as its database back end, but can be configured to use Oracle or SQL Server. The Enterprise edition requires the use of Oracle or SQL Server. Standard can be upgraded to Enterprise w/o data loss, according to the manufacturer. Emphasis on ease of customization and flexibility for any environment or requirement set. Instrument interfaces built into the product. Security levels + audit trail integrated.

Biotracker
Vendor/Abstract from http://www.limsource.com: Ocimum Biosolutions

Targeted towards biotech, pharmaceutical, pre-clinical trial, and oil/petroleum sectors. Integrated project management capabilities. Modular design including the following modules stock: Laboratory Administration (similar to Active Directory), Resource Scheduling, Project Tracking/Analysis/Result Archival, Inventory Management/Tracking, Sample Tracking, Plate Tracking, Reporting, Audit Trail, and Instrument Integration. Database management layer written in java and SQL-99 compliant.

BlazeLIMS
Vendor/Abstract from http://www.limsource.com: Blaze Systems

Generic LIMS system. Developed in MS Visual C++ and VB for use in a client/server environment and to ensure easy customizations. Compatible with any ODBC compliant database. Enterprise Plus version designed for use with a database server, Workgroup uses Microsoft Access. WebClient enables access to LIMS from any platform capable of using a web client. BlazeLINK is the instrument interface module, and handheld is a client designed for the PocketPC operating system. Additional modules available to manage inventory, manage product shelf live (Stability), and deal with analytical processing of radiation measurement. User level security/option configuration. Includes support for item routing and chain-of-custody.

blomesystem
Vendor/Abstract from http://www.limsource.com: AJ Blomesystem GmbH

blomesystem is both a LIMS development tool and a LIMS system itself. Off the shelf, they offer pharmaceutical, food/chemistry production, and commercial/environmental lab targeted LIMS products. All the off the shelf products were developed using their toolset, which is offered by itself. All utilize an Oracle back-end. The tool itself is a GUI used to create the system from database design/analysis to form creation and implementation. Access levels can be specified down to the user + screen level.

CaliberLIMS
Vendor/Abstract from http://www.limsource.com: Caliber Technologies Pvt Ltd

A generic LIMS specifically designed for user customization via menus. Oracle or SQL database. Emphasis on policies, security and user rights. Designed in a modular fashion. Standard modules include

Stability Test, Instrument Management, Reference Standards, Working Standards, Chemicals Management, Media/Culture Management, Columns Management, Out of Specification, Analyst Qualification and GMP Training. Internal instant messaging and email system. Includes guided tutorial to decrease any learning curve.

CAQ=QSYS LIMS
Vendor/Abstract from http://www.limsource.com: IBS AG

Modular based LIMS designed for raw material control, production inspection, and outgoing goods control. Supports inspections for R&D, application technology, competition analysis, and environmental/order analytics. Modules are listed and described @ http://www.ibs-ag.com/solutions/quality_management/caq_qsys_lims/module.php.

CCLAS LIMS
Vendor/Abstract from http://www.limsource.com: Comlabs Systems & Designs Pty. Ltd

Designed specifically for the minerals, mining, and metals industries, but has been used in environmental, petroleum, agricultural, and veterinary labs. Constructed using Visual Basic with Microsoft's COM + .NET technologies and uses the Windows standard GUI. SAP Certified for ERP integration. Supports RS232 instrument integration. Spreadsheet data entry mechanism. Supports ODBC databases such as Oracle and SQL. Supports thin clients via Citrix MetaFrame or Terminal Server.

Debra
Vendor/Abstract from http://www.limsource.com: LabLogic Systems Limited

LIMS for Absorption, Distribution, Metabolism, and Excretion studies. Windows platform product utilizing Oracle backend. Security functions restrict menu items and form functions. Assigned on a per user/per study basis. Integrated Document Management system. Barcode generation/reading. Bi-Directional instrumentation interface.

Discovery LIMS
Vendor/Abstract from http://www.limsource.com: CambridgeSoft

Explicitly an inventory, as opposed to information, management system. Designed specifically/solely for the discovery processes and contains no machine interfaces. Designed to be a lightweight application to initiate requests, track progress, and report results. Entirely web-based. Microsoft Server based, with MS Access or Oracle database.

Element Datasystem
Vendor/Abstract from http://www.limsource.com: Promium

Designed for use in an environmental analytical testing lab. Includes support for bidding/proposals, sample log-in, chain-of-custody, sample tracking, manual and automatic (from instrumentation) data entry, test batch creation, management reporting, turnaround time charting, audit trail maintenance, internal and external email interface, subcontractor management, Electronic Data Deliverable generation in popular formats, invoicing, automatic updating, automatic logout for security, Support for multiple databases, data review, general reporting, and analytical standards. Windows platform, Access, Oracle, and SQL databases.

EnviroLIMS
Vendor/Abstract from http://www.limsource.com: Xenco Software

Designed for QA purposes in environmental labs. Includes project management and data management functions, audit trail, bar-coding. Designed for screens and reports to be customizable to users with no programming experience.

FORMS II Lite
Vendor/Abstract from http://www.limsource.com: US Environmental Protection Agency (EPA)

Forms II Lite is a highly specialized LIMS. It was created by the EPA to aid in the paperwork process generated by collecting environmental samples from hazardous materials sites. It generates labels, tags, and chain-of-custody forms. Permits the tracking of samples from collection to submission. Does electronic data capture and has the capability to export data in xml format.

Galileo LIMS
Vendor/Abstract from http://www.limsource.com: InnaPhase Corporation

Designed to conduct permeability, enzyme inhibition, metabolic stability, enzyme kinetics, and protein binding experiments in an in-vitro environment for Biopharmaceutical research. Template driven LIMS. Experiments are designed by applying a template to a test compound. One-click experiment setup. Oracle 91/Windows 2000+ compatible.

Genetic Computer System
Vendor/Abstract from http://www.limsource.com: Shire Management Services

Contains a LIMS as part of its overall Genetic Database package. Used to track genetic samples in labs, while interfacing with the rest of the system. Includes connectivity to automatic karyotyping machines, automatic label printing, tracking of reagent supply, and both standard and customizable reports.

HORIZON LIMS
Vendor/Abstract from http://www.limsource.com: ChemWare, Inc.

Used in clinical, environmental, forensic toxicology, public health, manufacturing, and biological/chemical agent testing environments. Includes embedded scientific data management system to store raw data + human-readable files together with printed and/or scanned hard copy documents. This allows indexed searching of all the stored data items. Contains one-click generation of regulatory reports, electronic data deliverables, and litigation packages, including instrument data and chain of custody information. Also has a feature for web-based data access.

IMATIS LIMS
Vendor/Abstract from http://www.limsource.com: CARDIAC AS

LIMS designed for the medical environment. Also includes capability for lab automation. Reports created in MS Word and/or Excel. Instrument Manager to gather instrumentation information, calibration, and maintenance. Result Analysis module to view trend analysis ad other graphable metrics. Configurable security level by a variety of criteria. SSL encryption of data, VPN optional.

Key Solutions
Vendor/Abstract from http://www.limsource.com: Dataplex Technologies

Targeted towards meeting the needs of metal producers. Tracks a variety of data, including samples through testing, customer activity, sample turn-around-time, and instrument performance. Monitors operator qualifications, and can restrict access to functions based on them. Integrated QC/QA features to ensure best quality materials.

LAB-2000
Vendor/Abstract from http://www.limsource.com: Genesis Microsystems, Inc.

Access based LIMS, targeted towards small to medium sized labs. Vendor customizes LIMS on delivery to customer's client list and reporting needs. Provides sample tracking, technician scheduling, invoicing/financial tracking, management reporting, instrument interfacing, and regulatory reporting. Optional modules for customer information editing, quote generation, and MDL/QC batteries. Purchase includes 3-days onsite training.

LabAnalyst.NET
Vendor/Abstract from http://www.limsource.com: Finna Technologies, Inc.

LIMS developed entirely via the .NET framework and XML. SQL Server back end. Support for multiple labs in one database via internet connectivity. Security integrated w/ Windows AD/Domain security. Windows GUI interface. No specific type of lab specified. Test specifications, validation rules and rule enforcement all configurable.

LabCollector
Vendor/Abstract from http://www.limsource.com: AgileBio

Biology/Life Science targeted LIMS with 3 different versions. All are completely web based. Standard runs on a host server and is used to manage one lab. Enterprise has support for managing multiple labs on one server. ASP/Hosted requires no hardware invested; rather the hardware is rented from and managed by AgileBio. Administrative tasks are completely separated from user tasks and require a log-on to a separate interface. Current modules include Strains, Plasmids, Primers, Sequences, Reagents & Chemicals, Document Storage, Barcode generation, and Administration. Uses PHP and MySQL for a back end, coupled with IIS or Apache. Support for MacOSX, FreeBSD, Linux, and Solaris.

LabLite
Vendor/Abstract from http://www.limsource.com: LabLite LLC

3 different offerings with no specific type of target. Version 2.x has an access backend and is targeted towards smaller labs. SQL uses SQL Server for the backend and is their medium to large lab product. PC is targeted towards process control applications. All are written in Visual Basic and designed modularly, for easy "snap-in" of new features. Integrated with MS Office for reporting. All reports are customizable for user's need.

LabManager
Vendor/Abstract from http://www.limsource.com: Beckman Coulter, Inc (see InnaPhase Corporation)

Highly customizable LIMS. Designed to be able to be able to be built and maintained w/o needing to write any code. Client/Server based, with support for application and internet based access. Interfaces to lab instruments and Microsoft Office. Includes support for Stability Testing, Content Uniformity, Instrument calibration/maintenance, Analyst Training records, Solution management, forecasting, Lot management, Product regarding, Graphical trending, automatic sample registration, customizable reporting and SAP R3 integration.

LabMate Enterprise
Vendor/Abstract from http://www.limsource.com: Yullin Technology Company

Oracle based LIMS. Integrated Statistical analysis package. Full interface capabilities with any signal-emitting lab instrument. User-definable master data + reporting. Performance & Expense management, instrument calibration and lab equipment/supply inventory. Testing scheduling w/ priority control.

LabPartner
Vendor/Abstract from http://www.limsource.com: Tropical Software Solutions, Inc.

MS Access based LIMS. Base package includes sample tracking/entry, project/sample status monitoring, Work list creation, data entry, and report generation. Optional modules include QC reporting, QC trend analysis and control limits, invoicing, and electronic data deliverables.

LabPAS
Vendor/Abstract from http://www.limsource.com: Green Mountain Logic, Inc.

A so called adaptive LIMS using either Oracle or SQL Server. The vendor uses a so-called Adaptive Hook Technology to allow modifications to the LIMS, while not modifying any system code. This is supposedly to allow customization, while still allowing the vendor to support the system and offer upgrades. Included Process Automation System claims to allow easy mapping of workflow and tasks into the LIMS, as well as the creation of custom screens. Module based, with the follow modules offered: Lab Basics (standard module), Sample Management, Lab Metrics, Inventory, Ordering, Lab management, Instrumentation, Mobility (PDA support), Donor, Internal Communications.

LabPro
Vendor/Abstract from http://www.limsource.com: LabPro 2000 Ltd.

LIMS targeted for any type of laboratory. Coded in PROGRESS 4GL and utilizes PROGRESS DBMS. User definable testing ranges and specifications, including logical tests. Definable sampling schemes of both static and variable definitions. Multiple methods of result entry. Bi-directional instrument communication.

Laboras
Vendor/Abstract from http://www.limsource.com: Adifo N.V.

Targeted towards food/agricultural labs doing QC testing. Modules include QC Testing, Lab & sample organization, transmission of data/reports to external customers with billing, automatic sampling plan generation, shelf life checking, lab equipment interface, instrument examination/calibration, integrated mathematical/statistical analysis.

LABS/Q
Vendor/Abstract from http://www.limsource.com: iCD GmbH

Geared towards R&D, QA/QC, and pollution control labs. Based off an Oracle RDBMS. Includes CASE tools for LIMS customization and modifications without programming. Standard interfaces to SAP R/3, Protean, Movex, and Chromatography Data Systems.

LabSoft LIMS
Vendor/Abstract from http://www.limsource.com: Computing Solutions, Inc.

Windows/SQL based LIMS designed for the chemical, food/beverage, petrochemical, and manufacturing sectors. Utilizes a "logbook" style method for data + results entry. Integrated specifications module for manufacturing and customer specs. Statistical analysis integrated. Microsoft compatible. Audit trail of all actions. User/Function/Group security levels.

Labsys LIMS
Vendor/Abstract from http://www.limsource.com: LabSys Ltd

Multi part LIMS available for both Intel & AS/400 based servers working in conjunction with DB2/400, PROGRESS, SQL Server, or Oracle databases. Targeted towards pharmaceutical, chemical, and

food/beverage labs. LIMS Split into Process LIMS, QC LIMS, and Stability LIMS. Also offered is an instrumentation connection module.

LabWare LIMS
Vendor/Abstract from http://www.limsource.com: LabWare

LIMS designed for QA/QC & R&D labs in any sector. Developed using Microsoft Windows GUI. Architecture is MS Windows compatible servers with an OBDC compliant database. UNIX is also supported, as is Citrix for application delivery to end users. Emphasis placed on ease of client configuration. Specialized modules for stability management, inventory control, instrument calibration/management, user certification/training, secure reporting, investigation management, lot testing, charting and trending, and SAP interface. Interfaces also available to 3rd party document management systems.

LABWORKS ES
Vendor/Abstract from http://www.limsource.com: PerkinElmer

Windows based LIMS with no specific target. Standard application includes support for sample login, security, results entry, trending, QA/QC monitoring, data reporting, and data export. Optional modules for instrument management/calibration, process scheduling, COA/Product Quality Management, Personnel training, industrial pre-treatment, inventory management, calculations, instrument interface, quote generation, and statistical quality control. Support for bar-coding of samples and custom report generation is also available, as is automatic report generation.

lims+WARE
Vendor/Abstract from http://www.limsource.com: lims+WARE

Available for UNIX, Windows, ASP/Internet based, and internet based via leased hardware. Little to no information regarding capabilities or features is available online.

LIMS2000
Vendor/Abstract from http://www.limsource.com: AssayNet Canada Inc

Designed for mining and environmental labs. Can utilize NT security for user rights assignment. Interfaces for communication w/ lab instruments. Bilingual support for both English and Spanish simultaneously. Supports communication/use by remote labs. Does QC, quotation/invoicing, inventory management, and sample storage tracking. Uses Internet for communication via proprietary AssayNet web server.

limsExpress
Vendor/Abstract from http://www.limsource.com: Dynamic Databases

MS Access based LIMS for Windows OS. Designed for both stand-alone and network operation. Generic LIMS and includes 3 hours of customization (normally $70/hour) from vendor. Supports sample log-in, bar-coding, digital data storage for other files, Chain of Custody tracking, QA/QC, invoicing (with QuickBooks interface), inventory management, MSDS tracking, instrument maintenance tracking, import/export of data to CSV, Word, and Excel.

Limsophy
Vendor/Abstract from http://www.limsource.com: AAC Infotray AG

LIMS developed using OOP to permit maximum customization while retaining standardization between implementations. Uses “Pearl Principle” to show different properties/portions of data to different users based on needs and wants. Modular implementation. Standard modules include Test methods, parameters,

units, methodology, equipment, scope of examination, lists of limit values, specs, addresses, and user DB management. Additional modules add support for automation, substance module, documentation management and pool, inspection, control cards, lab book, multi-language data, multi-language interface, off-db, price list, sample series, product development, product management, reference substance, statistics, and billing. Supports Oracle, MS SQL, and Firebird DBMS with full export/import between supported platforms. Report versioning and audit trail.

LV LIMS
Vendor/Abstract from http://www.limsource.com: Trilogy Computers Limited

A portion of a larger package named LV Environmental, which is designed for water quality and environmental lab environments. LIMS supports contract management, quote generation, sample registration and organization, result entry and validation, review and release of results, certification and reporting, invoice production and general administration. Uses MS Windows GUI.

MADCAP V
Vendor/Abstract from http://www.limsource.com: Contec Group International Ltd

Specifically designed for the dairy industry. Developed in JADE and has its own proprietary database and thin client interface. Both manual and automatic data entry. Transport method information tracking. Variance analysis, statistical analysis, test specification and grouping, instrument calibration, sample definition. Web interface included for remote users.

Matrix Plus
Vendor/Abstract from http://www.limsource.com: Autoscribe

General purpose. Utilizes either Oracle or SQL Server. Supports multiple labs with different DB structures for each one. Modules available for batch registration, configuration tools, customer complaint management, event logging, frequency testing, instrument calibration and management, network administration, multi-sample/multi-test result entry, result import, run sheet creation, sample receipt/prep, stability study, and training records.

Matware
Vendor/Abstract from http://www.limsource.com: IMR Technologies LLC

Designed for manufacturing and commercial testing labs. MS Access based. Integrated with QuickBooks and MS Office. Manages client data, supports repetitive test/client data auto-fill. Built in email/fax engine. Label + barcode printing. Quote generation. Track equipment calibration.

Metabase
Vendor/Abstract from http://www.limsource.com: Summit Research Services

MS Excel based LIMS tailored to handling radioanalytical data from pharmacokinetic and metabolic studies. Custom sample management, protocol definition, data capture, data management, calculations, and reporting

MSC-LIMS
Vendor/Abstract from http://www.limsource.com: Mountain States Consulting

MS Access based LIMS for small to mid sized labs of all types. Single sample or batch login. Integration with MS Excel. Fax and email generation internal to application. Sample tracking, warnings, and scheduling. Reporting, charting and statistical analysis. Billing + personnel management. Integrated barcode support. Instrument calibration and testing record maintenance. Audit Tracking. SQL Query support.

NeoMate LIMS
Vendor/Abstract from http://www.limsource.com: Accelerated Technology Laboratories

Designed for newborn genetic screen laboratories. SQL Server or Oracle backend databases, Windows95 or later client OS. Data input via web interface, ICR scanning of blood cards, and HL7 import. Creation, inventory, packaging, and sending of kits to suppliers. Demographic tracking, Specimen receiving and tracking, Result Entry, QA/QC, Automatic instrument interface, Case management, Voice Recognition System for results retrieval. Web integration for data entry and result retrieval

Newton LIMS
Vendor/Abstract from http://www.limsource.com: InnaPhase Corporation

Designed for pharmaceutical testing labs. Thin client interface using Oracle/XML for data storage and manipulation. Java based code w/ J2EE compatibility on Windows, UNIX, and Linux servers. Features include QC Batch testing, Stability testing and data management, inventory, advanced approval mechanisms and workflows, environmental monitoring, Analytical methods development, Formulation development, flexible reporting, instrument integration, Document integration, and SAP integration.

NOVA-LIMS
Vendor/Abstract from http://www.limsource.com: Novatek International

Modular LIMS designed to support a variety of industries with different modules. Modules include Stability Program (stability control for R&D/QC), Environmental Monitoring Program (health care + food industries), DATA(Document management, audit, and training), Finished Product Analyzer(for finished product testing), Raw Material Analyzer(testing of raw materials and incoming packaging components), Preventative Maintenance and Calibration (manage lab equipment), Automated Packaging Component Analyzer (verify incoming components against a master copy), The Column Organizer (tracking and management of HPLC and GC Columns), and Sleep Vision (capture of 2 audio + video streams, mainly for sleep lab studies).

NWA LIMS
Vendor/Abstract from http://www.limsource.com: Northwest Analytical, Inc.

Analytical laboratory LIMS, running on Windows 2000 with a Pervasive SQL server database. Text based interface w/ user configurable menus. Designed for lab personnel to manage and configure system by themselves. Automatic Sample creation. Data gathering from instruments via RS-232 interface. Customizable reporting.

PLIMS
Vendor/Abstract from http://www.limsource.com: Sarla Technologies (formerly Pidilite Systems and Engineering Services)

Targeted towards the pharmaceutical industry. Oracle DBMS based, Windows NT server, 9x clients. Sample Management, Specifications Management, Resource Management, SOP Management, Contacts Management, and pharmaceutical industries modules.

PowerLab
Vendor/Abstract from http://www.limsource.com: SYSWARE Healthcare Systems
LIMS designed for hospital, healthcare, veterinary and pathological labs. . HIPAA compliant. Windows based solution offering support for Citrix and web clients, plus remote dial-in access. Supports all hospital laboratory disciplines, QC/QA, and epidemiology reporting.

ProteusLIMS
Vendor/Abstract from http://www.limsource.com: GenoLogics Life Sciences Software Inc.

Life sciences targeted LIMS. Modular based. Java/J2EE based solution. Any SQL Database can be used as a back end. Standard modules are BaseSys (sample tracking, data security, and project management), ProFlow (Task, Workflow, and Personnel management), and Lab Client (client/collaborator relationship management). Optional Modules are GelManager (for use with lab gels), MSpecManager (for mass spectrometry), and ProteinManager (protein discovery and identification).

Q-DIS/QM
Vendor/Abstract from http://www.limsource.com: CreonLabControl Inc

Supports most lab functions with an emphasis on QC. Supports manual and automatic order generation, including automated/scheduled orders and via a web interface. Bar-coding used for sample handling. Automated results entry/analysis, with automatic validation and graphical representation. Decision/Acceptance includes system generated suggestions derived from validation rules. Certificate of Compliance procedures. Additional modules add support for stability studies, maintenance of reference substances, complaint management, and recipe/formulation management.

SampleManager
Vendor/Abstract from http://www.limsource.com: Thermo LabSystems

Designed for any type of lab, especially those in corporations looking to standardize a LIMS across all functional types of LIMS. Some customization geared towards pharmaceutical, petrochemical, water, and food industries. Easy integration into SAP/R3. Windows GUI/OS Based.

Sample Master Pro
Vendor/Abstract from http://www.limsource.com: Accelerated Technology Laboratories, Inc. \

Enterprise-class generic LIMS. Other versions available for smaller labs. Based on MS Access, but uses Oracle or SQL Server for enterprise data storage. DB Supports referential integrity, OLE, and ODBC. Modules/Features are: Sample Tracking (w/ integrated bar-coding), Data Entry, Sample Scheduling/Stability, QA/QC, Electronic Data Transfer, Chemical Inventory, Resource Management (instrument calibration and personnel training), CRM, Time Tracking, and LIMS Maintenance. Integration w/ MS Office.

SLIM
Vendor/Abstract from http://www.limsource.com: Metrics, Inc.

Designed for drug stability testing labs. Written in Visual C++ to run on MS Windows clients with an Oracle or SQL Server database. Generates test schedules, including multiple lab test and product/test specific schedules. Interactive, pre-defined, and automatic reporting. SLIM is LIMS only, optional SLIM-STAT+ adds statistical analysis, graphical trending and shelf-life analysis.

SQL*LIMS
Vendor/Abstract from http://www.limsource.com: Applied Biosystems (formerly PE Biosystems)

Oracle based LIMS with a modular construction for customization towards specific purposes. Supported on many OS', including Solaris, HP-UX, and OpenVMS, as well as Windows. Support XML for data interchange and Web Services, for accessibility. Focused towards Manufacturing QA/QC.

STIS, Sample Tracking and Inventory System
Vendor/Abstract from http://www.limsource.com: ChemSW

Multi-sector LIMS. Tracks samples, sample inventory, and testing results. Windows GUI based with Oracle back end.

TLIMS (Trials Laboratory Information Management System)
Vendor/Abstract from http://www.limsource.com: Ingensis Limited

Designed to manage clinical trials. Data entry supports validation against defined parameters and previous data. Instrument interfaces support bi-directional communication for most common pieces of equipment. Full electronic audit trail. Both manual and electronic bar-coding. QC module to permit statistical analysis of batches. Referrals module to track work sent to outside labs. Integrated billing.

Tribal-LDMS
Vendor/Abstract from http://www.limsource.com: Tribal Software, Inc.

Access-based LIMS designed for smaller laboratories. Company offers source code with any product purchase to aid in end-user customization. Oracle or SQL Server databases optional. Bar code sample login. 10 levels of security. Multiple sample log-in. OLE capabilities to MS Office. Electronic data acquisition/instrument interface. Accounting module for invoicing, customer history, and statements. QC module for statistical analysis. Tracks instrument calibration/maintenance, chemical & Supply information, MSDS information, and employee information.

UVIS
Vendor/Abstract from http://www.limsource.com: The Ross Group

Veterinary hospital LIMS. Modular based. Oracle Backend. Business administration module provides Accounting, Billing, Front Desk/Cashiering, and Demographical analysis. Hospital module tracks medical records, order requests/results, and integrates with laboratories via electronic requests. Inventory Management includes barcode and automatic order generation. Pharmacy permits electronic prescriptions with approval functionality, controlled substance audit, and interfaces to drug dispensing machines. Laboratory module features accession management, equipment interface, results reporting, lab production/income reporting, and inventory.

VisuaLab
Vendor/Abstract from http://www.limsource.com: Aurora Systems

Designed for Clinical, diagnostic, and veterinary labs. Any SQL database can be used as a backend. Work list reporting. Automatic fax/e-mail. Imaging, Auditing, label/bar-code printing, instrument interface. Multiple security levels.

Visual LabPro
Vendor/Abstract from http://www.limsource.com: Camin Cargo Control, Inc.

Testing laboratory LIMS. Developed w/ Microsoft Visual Studio. Integration with MS Office and QuickBooks. Fully automated QC system. Automatic data gathering from instruments. Audit Trail, object-based security, and transaction controls. Stores OLE compatible documents with records.

Wavefront LIMS
Vendor/Abstract from http://www.limsource.com: Wavefront Software

Microsoft SQL Server/VS.Net based LIMS. Also uses HTML and Java technologies. Designed for small-to-mid sized labs. Generates Electronic Data Deliverables. Interfaces with lab instruments, MS Office, and

CDS/ERP solutions. Features Sample Management, Work Order Management, File/Image attachments to work order or sample, Test Management, Result management, User management, workflow management, and QA/QC.

Watson LIMS
Vendor in the USA: InnaPhase Corporation

Highly specialized to support DMPK/bioanalytical studies in pharmaceutical development. Features flexible study design, automated sample management, Assay/method standardization and management, "seamless" data exchange, import, and instrument interface, data analysis, reporting, and regulatory/security compliance.

Wildtype Linx System
Vendor/Abstract from http://www.limsource.com: Wildtype Informatics

Custom-built LIMS systems. A Java based web server forms the heart of the system, and as such can run on any platform that supports JDBC/ODBC compliant database programs. All communication is done via XML, allowing the company to offer a service to integrate lab robots and machines into the LIMS. Supports data delivery to all XML compatible platforms, including wireless phones and PDA's. Task screens can be restricted by user or job role, and only utilize HTML formatted web pages.

WinBLISS
Vendor/Abstract from http://www.limsource.com: Baytek International

LIMS designed for chemical, petrochemical, and pharmaceutical process control labs. Interfaces to plant control systems, audit trails, fax interface. Supports RS-232 communication for data acquisition from instruments. Interfaces available for SAP and other ERP systems.

WinLIMS
Vendor/Abstract from http://www.limsource.com: Quality Systems International (QSI)

Generic LIMS system. Claims to include all functionality required for Mineral/chemical, pharmaceutical, food/drink, environmental, healthcare/cosmetics, and petrochemical industries. Server can be any platform, as long as it supports an ANSI SQL relational database. Standard windows, web-based, and PocketPC clients are available.

APPENDIX E – FORENSIC LIMS VENDOR REVIEWS

Porter Lee Corporation

CRIME FIGHTER BARCODED EVIDENCE ANALYSIS STATISTICS AND TRACKING (BEAST)

COMPANY OVERVIEW

In 1995, Porter Lee Corporation started development of a new generation of evidence management products for both Police Agencies and Crime Labs. Porter Lee was initially founded when two software developers were contracted by the Northern Illinois Police Crime Lab to develop software that would satisfy the American Society of Crime Lab Directors' requirements for Crime Labs. After project completion, Porter Lee Corporation started marketing products within the same product line across the United States, and even acquired several international customers.

The current stakeholder community for Porter Lee Corporation includes over 250 Police Departments and over 50 Forensic Crime Laboratories. With highly trained and experienced staff that possesses extensive analytical forensic laboratory experience in addition to computer technical skills, Porter Lee Corporation is able to more effectively work and understand its customers, possessing a high level of understanding about both the varied needs of end-users, and providing guidance to administrators.

Porter Lee Corporation makes use of bar code technology to effectively track the evidence from the initial scene, through the property room, to the crime lab, and finally through possible legal proceedings.

Partners

Product Line

Software

LIMS
Laboratory Management and Reporting System

Quarter Master
Equipment and Asset Tracking System

Evidence Management System
Bar-coded Property Room Evidence Management System

COBIS
Combined Ballistic Identification System

Medical Examiner System
Morgue Intake and Body Inventory System

CODNA
Convicted Offender Database

Mugshot System
Digital Photo Capture and Lineup System

VINcheck
Portable Drivers License and License Registration Checking

Equipment

Barcode Printers

- Desktop
- High Volume
- Portable

Barcode Scanners

- 1D (Linear Barcodes)
- 2D (Linear & PDF417)
- Wireless (Linear Barcodes)
- Batch (Linear Barcodes)

Supplies

Barcode Labels

- Micro Evidence Labels
- Small Evidence Labels (Standard)
- Large Evidence Labels

Barcode Printer Ribbon

- Desktop
- High Volume
- Portable

Clients

Since 1996 Porter Lee Corporation has served Police Departments and Crime Laboratories through almost all 50 states, and has also acquired some international clients as well. Specific counts of stakeholder groups, as provided by Porter Lee Corporation, are provided below:

North America

71	Lab Agencies Installed
254	Police Agencies Installed
61	VINcheck Agencies Installed
5	Medical Examiners / Coroner Agencies Installed

International

- Forensic Sciences Center Office Of The Attorney General, Barbados, West Indies
- ALSTE Technologies GmbH , Babenhausen Germany
- Hong Kong Police Department
- Hong Kong Identification Bureau
- Crime Scene Management, SAPS South Africa

PRODUCT OVERVIEW

The Crime Fighter Bar Coded Evidence Analysis Statistics and Tracking (B.E.A.S.T.) is a Microsoft Windows application that provides a LIMS implementation, complete with bar-coding support, and operates on Windows 2000 and Windows NT server platforms. The system integrates a complete Police Property Inventory System with an advanced Laboratory Information Management System. Porter Lee Corporation designed the system to be customizable with respect to laboratory policies.

The software package provides Forensic Laboratory Information Management System for crime laboratories and Evidence Management System for police agencies. It is integrated with Symbol Technologies PDF417 bar code to speed evidence check-in. User-defined Report Wizards are included to assist in both report writing and statistical data analysis. It provides laboratories with a robust system to record and track case-related information, such as multiple-item cases, case resubmissions, item and sample information, sequencing of multiple types of analysis for multiple disciplines, note taking, and finally, report generation.

The Crime Fighter BEAST also manages information outside of case-related activities. This information, some of which has been touched on within the body of this whitepaper, includes analyst training, research, presentations, ordering, billing, equipment maintenance, and quality assurance.

Systems Requirements

Client Requirements

- Platforms: Windows 98, 2000, Me & XP
- 1.2 GHz processor or higher
- 2-DB9 Serial Ports
- 128 Mb RAM

Server Requirements

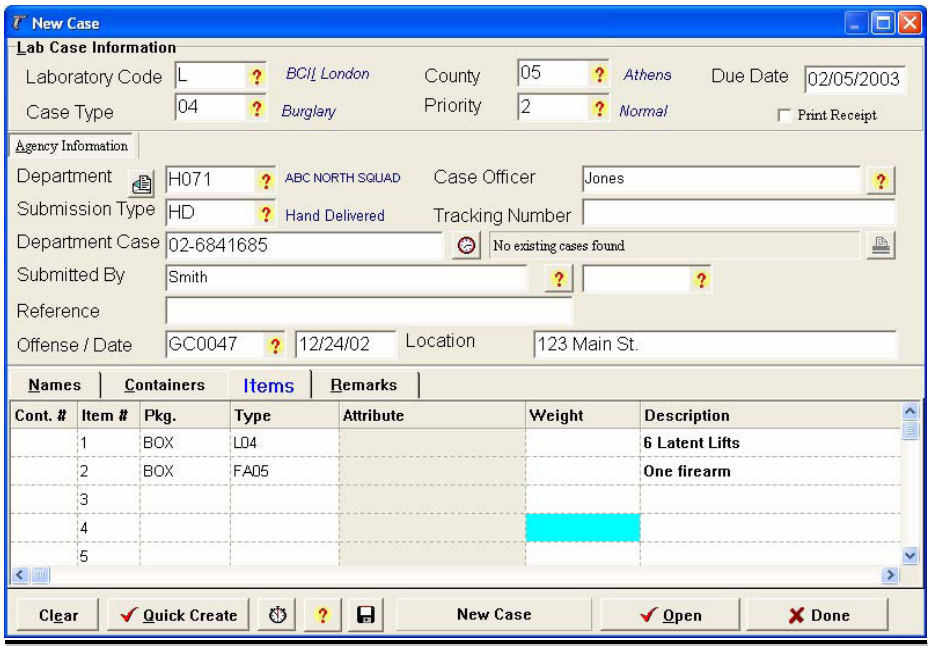
- Platforms: Windows NT, 2000
- 2.6 GHz processor or higher
- 2-DB9 Serial Ports
- 1 Gb RAM

Product Features

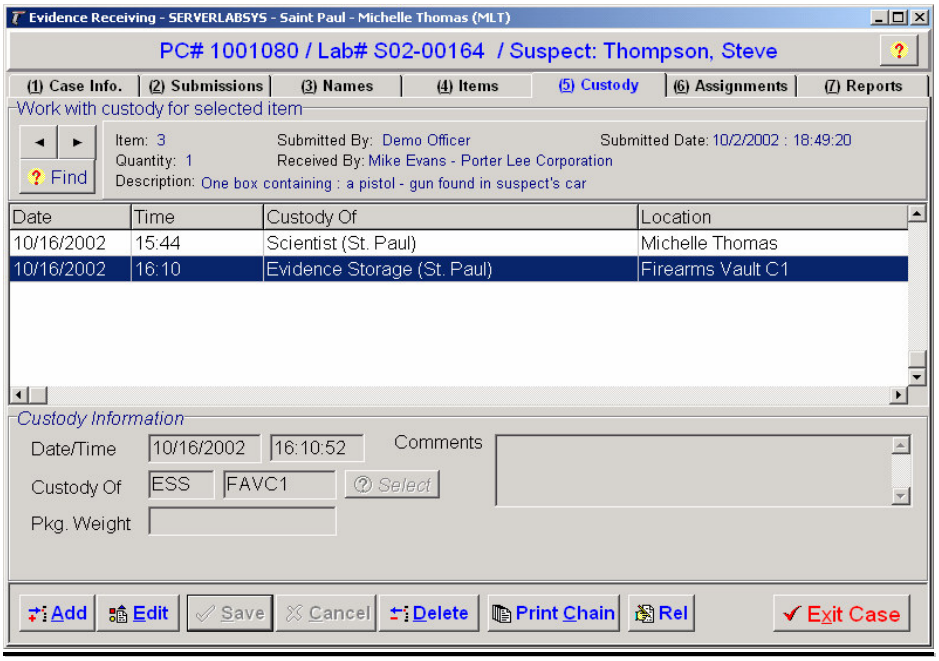
- Customized Lab Reports Using "Matrix" Technology
- Integrated Police Property Inventory System
- Backlog Reporting By Section
- Customizable security functions
- Extensive Management and Statistical Reports
- Laboratory Asset Management System
- Digital Image Capture
- Instrument Interface

Screenshots

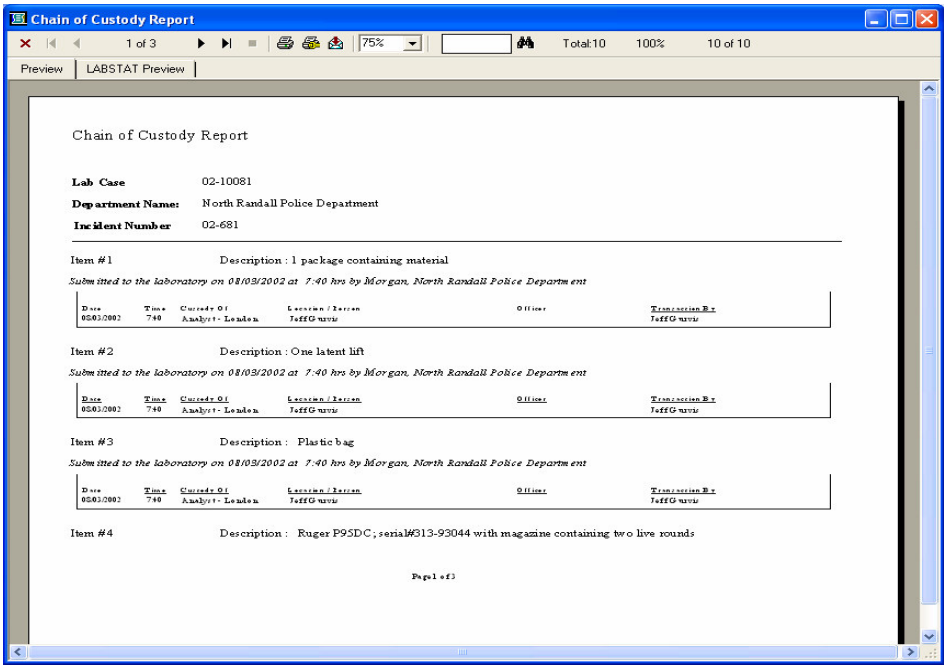
Evidence Receiving Main Screen



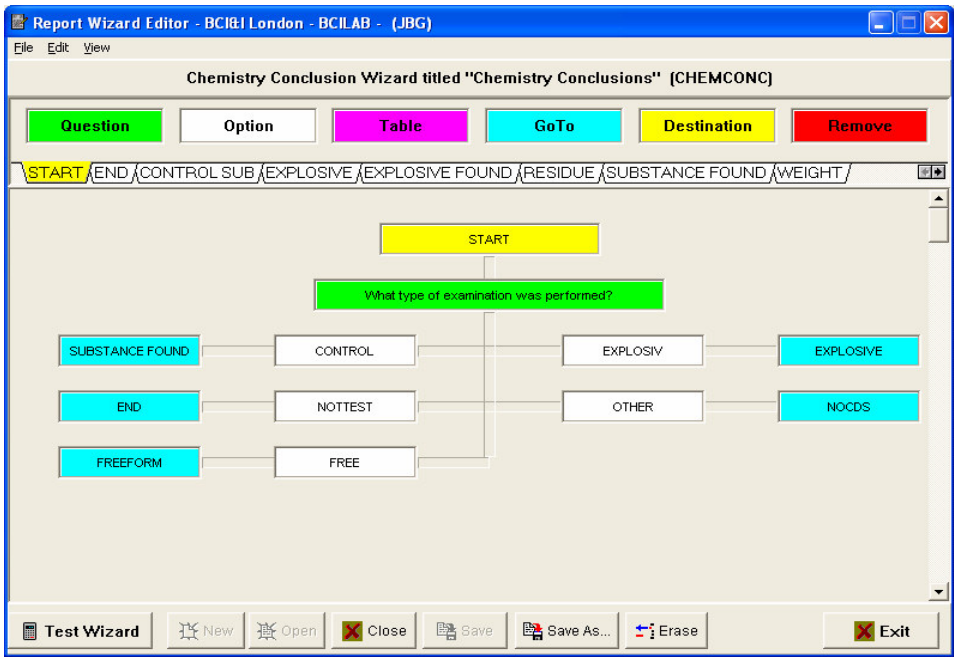
Evidence Receiving New Case Screen



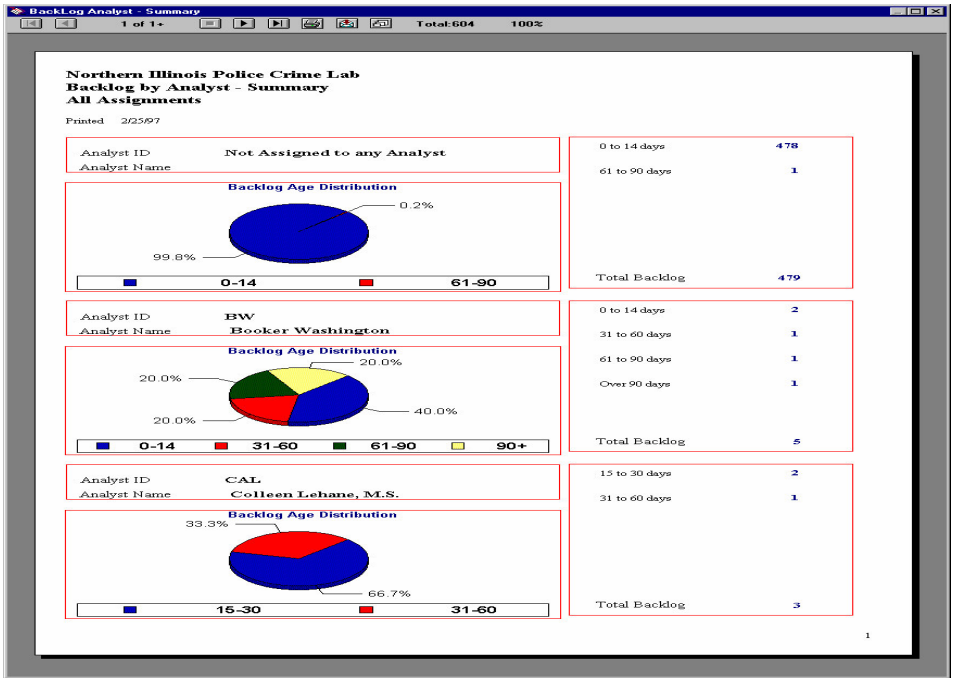
Evidence Receiving Custody Information Screen



Case Report Chain of Custody Screen



Report Wizard Editor Screen



Backlog by analyst - Report

Contact Information

Porter Lee Corporation - Crime Fighter BEAST

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Customer Support: support@porterlee.com

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Forensic Technology Inc.

B.A.R.D. LIMS

COMPANY OVERVIEW

Forensic Technology is a subsidiary of Walsh Automation Inc., a global leader in the systems integration and consulting engineering industries. Formed in 1990, Forensic Technology developed tools for forensic science applications with an emphasis in firearms identification. Pioneering automated ballistics identification, Forensic Technology continues to be a leader in technologies for forensic and crime agencies. Based out of Quebec, Canada, Forensic Technology has a global corporate presence that includes Thailand, Ireland, Republic of South Africa and United States.

Forensic Technology employs a dedicated team of engineering, forensic, and law-enforcement professionals. This allows Forensic Technology to continually research product improvements based on client needs, new trends and information technology advances in order to continue to deliver an effective and innovative technological tool for the industry.

Partners

Clients

PRODUCT OVERVIEW

Forensic Technology's flagship system is b.a.r.d. - which stands for *b*eyond *a* *r*easonable *d*oubt. B.a.r.d. organizes and maintains a secure repository of case and evidence management, and is capable of securely networking with the criminal justice system for the disposition of case and evidence information. This allows authorized specialists from the entire law-enforcement community to access, compile, and analyze information for any case. The b.a.r.d framework is based on the notion of information sharing within the law-enforcement and criminal justice system. This framework is composed of a set of core modules and components.

B.a.r.d-LIMS

Forensic Technology's b.a.r.d LIMS is a complete forensic LIMS targeted to meet the needs of any size forensic laboratories. It provides a secured environment for evidence and analytical work. B.a.r.d. is both ASCLD/LAB and

ISO 17025 (ISO Guide 25) compliant. B.a.r.d LIMS supports most of the forensic lab sections such as chemistry, toxicology, latent prints, DNA, and trace evidence.

Other Modules

Inside the b.a.r.d framework, LIMS applications may co-exist with other modules which act to enhance the overall capabilities of the system. Following is a list of available modules; for more information please visit www.forensictechnologyinc.com:

- **b.a.r.d ERP**
- **b.a.r.d Link**
- **LimsLink**
- **b.a.r.d Data Management**
- **IBIS b.a.r.d Interface**
- **eb.a.r.d**

System Requirements

Client Requirements

- Pentium III processor or greater
- Windows 2000 or Windows XP
- 256 MB of RAM
- 250 MB free hard disk storage capacity
- CD ROM

Server Requirements

- Dedicated server with Intel Xeon processor
- Windows 2000 Server
- Two RAID-5 disk arrays

- 1GB memory

Product Features

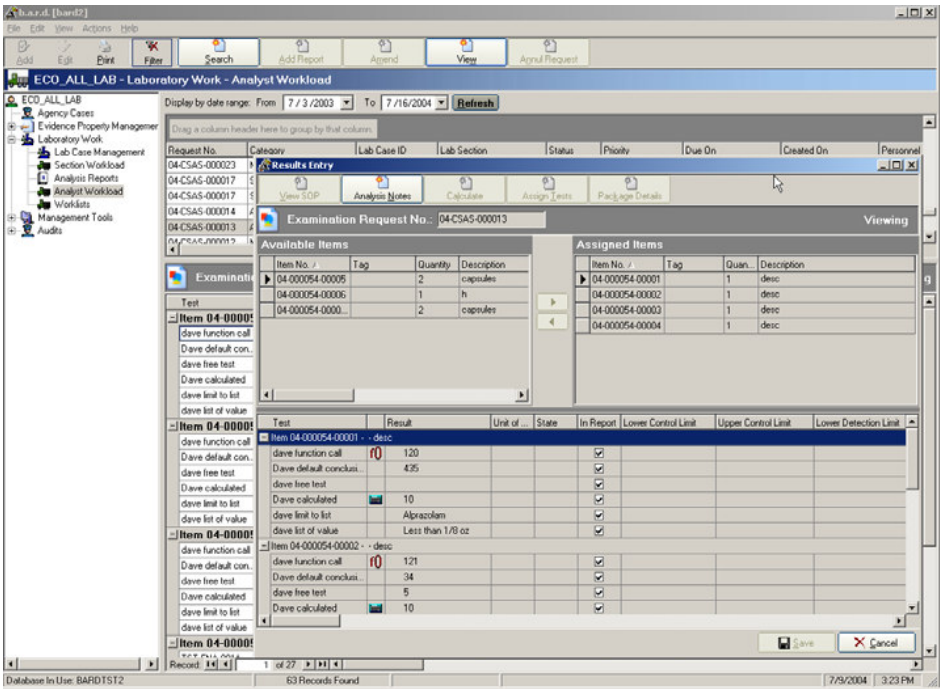
General Features

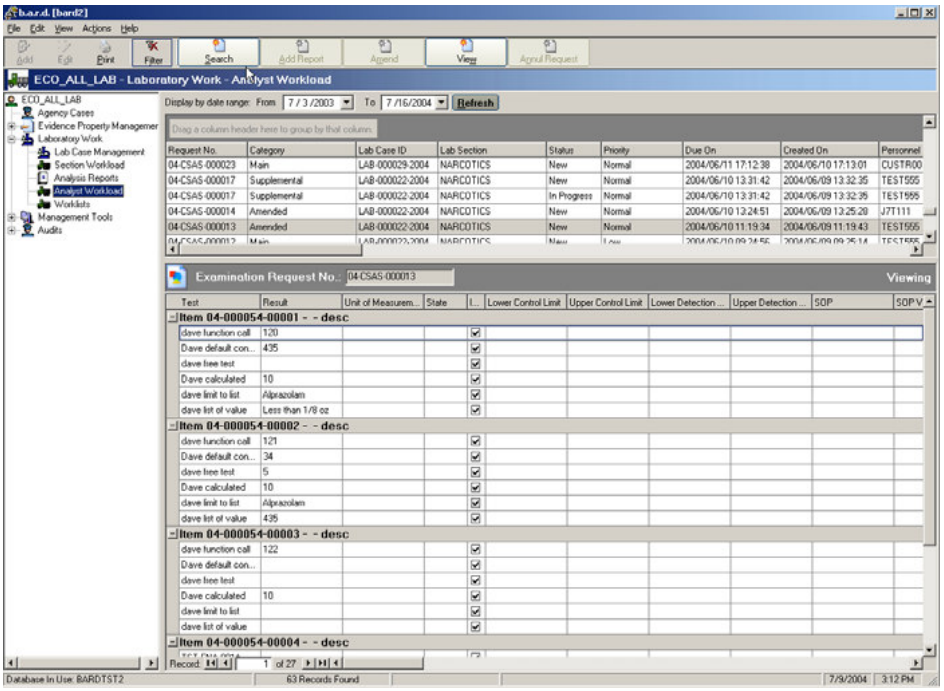
- Laboratory Case, Submissions & Items
- Documentation of Incident & People
- Analysis Requests, Assignments & Worksheets
- Sample Management
- Results Management
- Analytical Instrument Integration
- Analysis Report
- Administrative & Statistical Reports
- Quality Control / Quality Assurance Functions
- Inventory Control
- Instrument Management

Technical Features

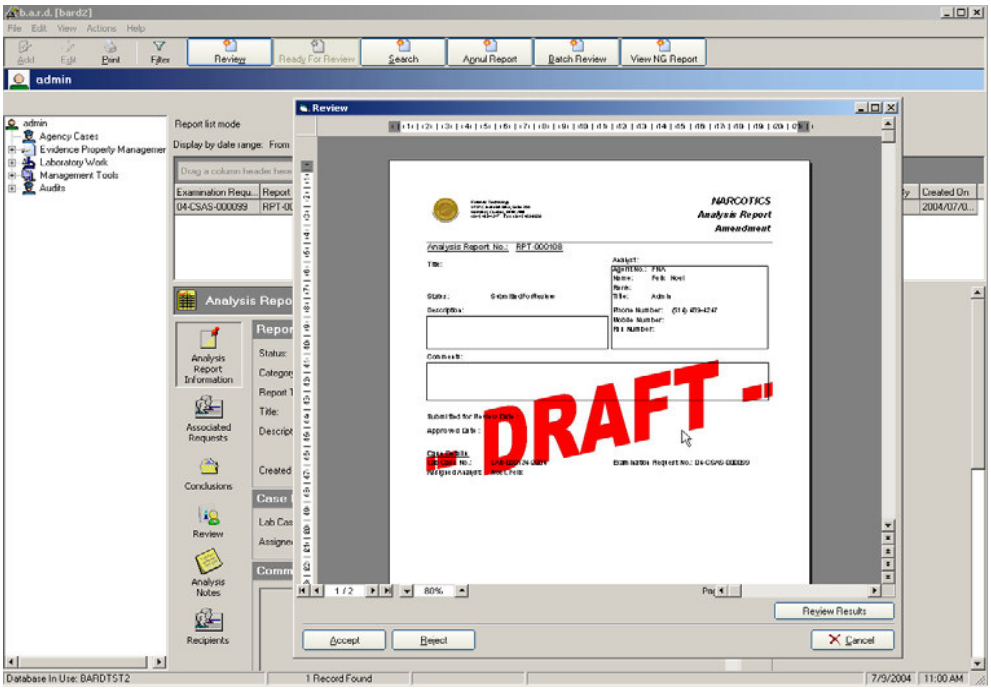
- Server operating system compatible with Windows 2000 or better
- Client stations compatible with Windows 2000 & XP
- Operates in a distributed computing environment as a client-server
- Open and flexible user presentation services with end-user configuration
- User-friendly and flexible reporting tool integrating MS-Office programs
- Report templates that can be adapted for specific report layouts;
- State of the art bar code technology for managing the chain of custody
- Electronic signature enabled
- Biometric fingerprint login and transfer of custody enabled

Screenshots





Analyst Worksheet Screens



Analysis Report screen

Contact Information

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Justice Trax, Inc.

JUSTICE TRAX LIMS-PLUS

COMPANY OVERVIEW

This privately-held, employee-owned company emerged from a division of AG Communication Systems - a joint venture of AT&T's Lucent Technologies and GTE - before being acquired by its employees in May 2000. Since 1995, JusticeTrax has provided quality software solutions to the criminal justice professional. Its main product, LIMS-plus, is a LIMS solution designed for forensic laboratories of all sizes and is designed specifically for the crime laboratory. This product is the evolution of AT&T's 1994 venture into the LIMS market, when they developed AT&T LIMS-plus; subsequently renamed JusticeTrax LIMS-plus. To date, around 1500 crime labs across North America are using JusticeTrax systems.

JusticeTrax Inc. was incorporated on May 19, 2000 and is headquartered in Mesa, Arizona.

Partners

Product Line and Services

JusticeTrax Inc. offers a growing line of software solutions and support services. With over 2500 users across North America, JusticeTrax is a well-

known presence within the LIMS community. Currently, they offer the following products and services.

Path Assist

Path Assist is a case management tool. Through supporting customization of the interface, the case information tracking process is enhanced. Path Assist also automates the preparation of documents and reports.

ChainLinx

ChainLinx is a stand-alone application for property and evidence. It provides detailed, secure chain-of-custody and evidence handling processes through the creation of hierarchical evidentiary relationships and maintenance of a detailed chain-of-custody path for each item.

Platform Consulting

Platform Consulting is a technical support service designed to assist laboratories who have access to little or not IT support. Platform consulting offers support for issues not related only to the product itself, but with the system(s) running the product. This service can be a boon to smaller laboratories, or laboratories with reduced or nonexistent IT budgets.

Custom Reports Consulting

Customers often choose to use JusticeTrax expertise for designing final report templates or statistical reports using Business Objects' Crystal Reports. JusticeTrax offers consulting services to design reporting templates to meet specific laboratory needs.

Training Services

Training Services are available on-site at JusticeTrax headquarters in Mesa, Arizona. JusticeTrax provides training utilizing a state of the art mobile computer classroom. Training is available for all laboratories' personnel.

Adjunct products

JusticeTrax offers a host of add-on products to allow you to further extend the usability of your software solutions. Additionally, JusticeTrax has experience in developing custom applications, integrating with mature systems, and migrating legacy databases.

Clients

- 2500 users across North America

PRODUCT OVERVIEW - LIMS-plus

LIMS-plus is a laboratory information management system designed specifically for the forensic laboratory. It includes secure evidence tracking, case management, and analysis and reporting automation. LIMS-plus also includes an end-to-end DNA analytical module to enhance both the speed and accuracy of this critical laboratory function.

The product was originally developed at the core laboratories of a number of state police organizations for forensics laboratories, and is designed to manage multiple evidence examinations across several lab sections.

Product Features

Role Based Security
Field-Level Auditing
Automatic Log Off
Chemical Inventory
Imaging System
Instrument Integration
Web Enabled
Evidence Reconciliation
Hierarchical Evidence
Z-Order Chain-of-Custody
Multi-Site Support
Rapid Case Entry
Cascading Services
System-Wide Batch Processing
Advanced Quality Assurance
Improved Reporting
Trusted by the Most Demanding

Product Advantages

- Advanced Bar Code Technology
- Consistent Management Reporting
- Customized Lab Reporting
- Powerful Lab Management Tools
- Superior Security Features
- Exclusive PreLog Application

Contact Information

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Promadis

CASEMAN

COMPANY OVERVIEW

Promadis, formerly known as Shaw Solutions, is an Australian firm that owns an extensive list of technology products, their specialty being the creation and implementation of computer systems. Serving several industries, Promadis has the opportunity for a significant knowledge base regarding the critical factors in automating business processes and implementing computerized systems. For specific information on Promadis' line products and services, please visit their website at www.promadis.com

PRODUCT OVERVIEW – CASEMAN

Promadis own version of a Laboratory Management Information System is fully and comprehensive system, specifically design for forensic applications. It is a modular system that fully integrates with other Promadis products, expanding into a fully integrated package. CaseMan coordinates and manages procedures needed to be performed on different cases. Once a case has been received, CaseMan can automatically assign the staff and resources necessary to complete the task. It also supports automatic information collection from analyzers, barcode integration, and associations of cases with database records.

Product Features

- Case Management
- Blood Alcohol
- DNA
- Chemistry (Drugs Module)
- Administration Reports

- Biology Reports
- Management Reports
- Ad-hoc Reports
- Jobs Query
- System Functions

Promadis offers the following modules that can be integrated with CaseMan:

- PROMADIS DCI – Digital Camera Interface
- PROMADIS Imagine – Automated image capture
- PROMADIS Financials – Supports the financial management needs of an organization, like Accounts Payable, Accounts Receivable, Asset Management and Payroll.
- PROMADIS Central – Automated Report Distribution

Systems Supported

Microsoft	Unix	Linux	Other Technologies Supported
Microsoft Windows Server NT Microsoft Windows Server 2000	IBM AIX HP Unix SCO UnixWare	Red Hat Linux	SQL relational and post-relational structures Online Transaction Processing and Online Analytical Processing Open Database Connectivity Crystal Reports

Contact Information

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Contact: Peter Fulton

StarLIMS Corporation

STAR LIMS

COMPANY OVERVIEW

StarLIMS Corp. has more than 15 years of experience in the laboratory information management systems domain. Headquartered in Florida and with 36 offices around the world, StarLIMS is considered one of the fastest-growing LIMS vendors worldwide. StarLIMS Corp. has laboratory information management systems tailored by different industries – aside from forensics, these sectors include:

- Chemical
- Clinical
- Environmental
- Food
- Petrochemical
- Pharmaceutical and Public Health
- Government Agencies

StarLIMS' 15-year track record has earned them recognition and has proven them as reliable and robust systems, serving as a platform for straightforward conversions of legacy systems. For more information about the individual products offered for each of these laboratory sectors visit StarLIMS' website at http://www.starlims.com.

PRODUCT OVERVIEW

StarLIMS is responsible for the successful implementation of laboratory management systems in multiple entities across different market sectors. One such sector is the forensic market, which relies heavily upon the accurate collection of information critical in the resolution of a legal process. StarLIMS' platform is based on a flexible multiple-tier architecture containing functionally-rich components. This systems design enables the user to have more control over both workflow and style of the total LIMS implementation.

Product Main Features

- Document Management – The document management feature provides tools for capturing, storing, retrieving, parsing and sharing the complete set of information demanded in today's laboratory environment. This feature enhances the ability of scientific reporting by easing the extraction of data and providing the necessary tools for querying and analyzing data.

- Web Services – Web Services are a way of providing self-contained applications that are located and accessed through the Internet, thus allowing the LIMS to interface with other key business applications.

- Multi-Tier Adaptable Architecture – Multi-Tier Architecture splits the applications into different components layers – Technology, Business Rules, and Database Tiers. Each layer may be thought of as a module, and each module is allowed *controlled* access to the other layers, thus aiding in the protection of end-to-end system integrity through damage minimization and control. While this may extend more flexibility and control over the information and the operations contained at each module, it is also vital to fully understand the implications of a modular system.

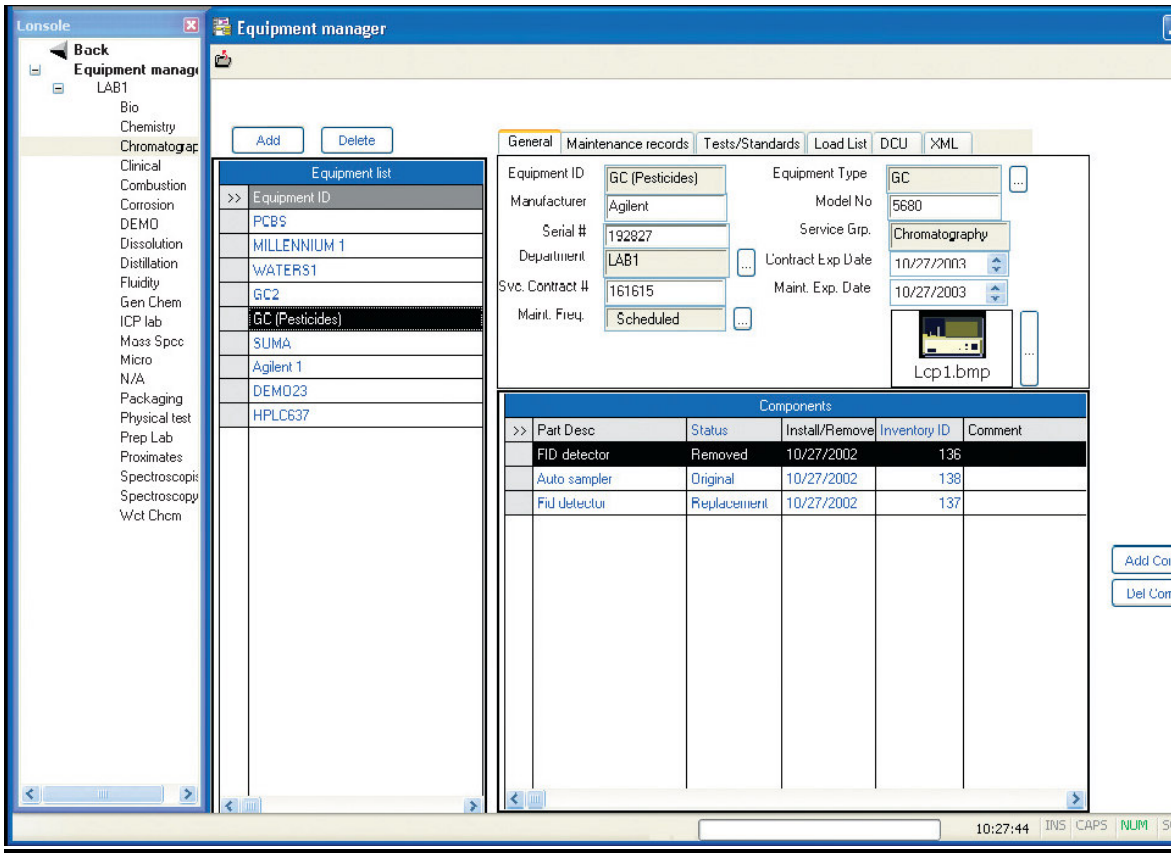
- Workflow Management – The workflow management feature consists of a knowledge repository that contains operations functions which the organizations can utilize to schematize and operationalize unique – and potentially proprietary – workflows. StarLIMS deems this notion "Personalized Content Delivery".

- Certified Interface – Certified interface represents the culmination of a partnership between StarLIMS and Waters, in which StarLIMS interacts with Waters Chromatography Data System (CDS).

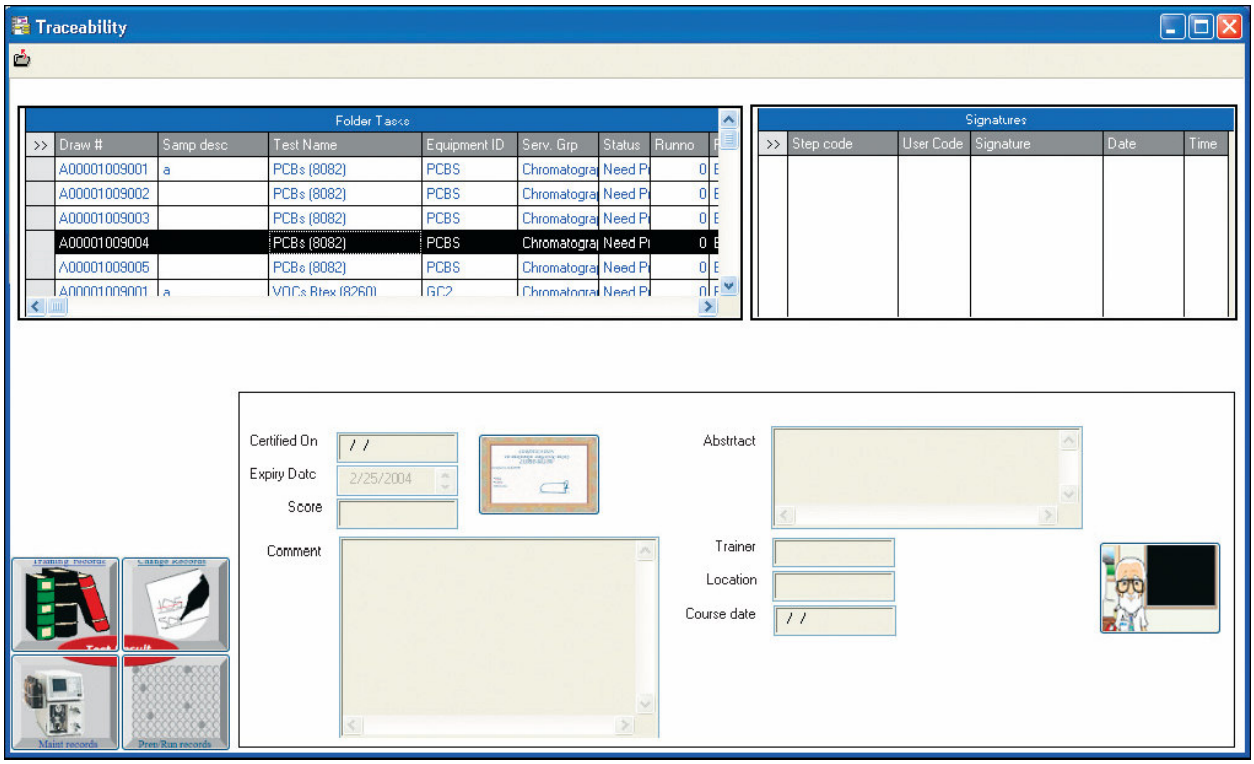
Additional Features

- Work Assignment
- Results Entry
- StarLIMS Data Capture Utility (DCU)
- Review & Approval
- Reporting & Queries
- Crystal Reports
- Audit Trail

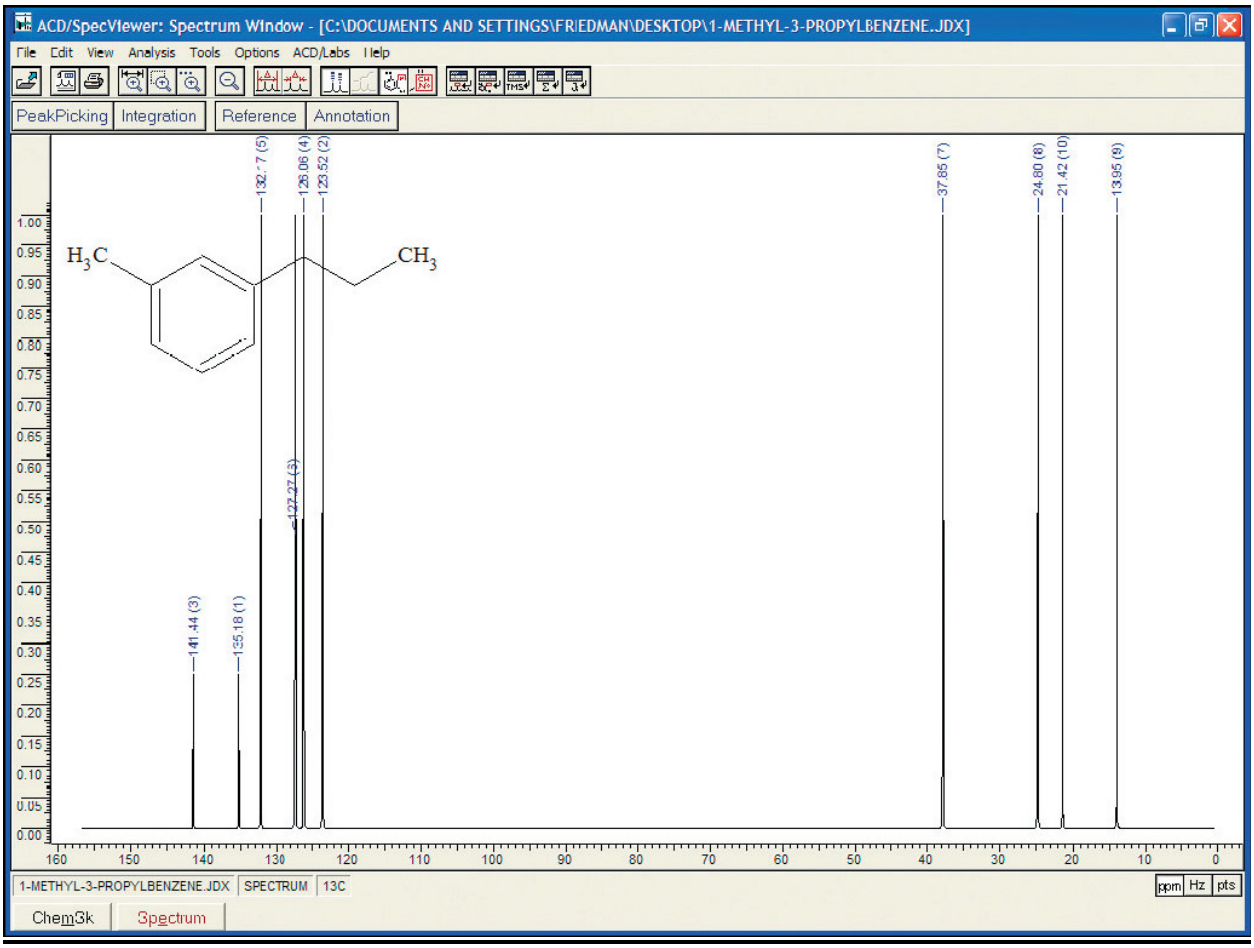
Screenshots



Equipment Maintenance View



Training Module with Electronic Signature Support



GCMS Spectrum Output and Compound Visualizer

Contact Information

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APPENDIX F – CONJOINT ANALYSIS

Aggregate Results

Average Utility Values: Aggregate

	Total
The LIMS supports Pre-Logging by integrating with Agency Evidence Management Systems for initial data input	31.41
The LIMS supports the importation of Pre-Logged Data	24.89
The LIMS does not support importation of Pre-Logged Data	-56.29
Data about cases and evidence without any form of Data Entry automation	-49.73
Data about cases and evidence with some form of Data Entry automation	18.53
Data about cases and evidence with a high level of Data Entry automation	31.20
The LIMS only supports typed commands for Navigation	-51.36
The LIMS supports GUI for Navigation	-4.48
The LIMS supports both typed commands as well as a GUI for Navigation	19.77
The LIMS supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation	36.07
Only one Screen can be opened at a time	-46.44
Multiple Screens can be open simultaneously	46.44
Cases can be grouped based on the submitting agency	41.65
Cases cannot be grouped based on the submitting agency	-41.65
Computers that interface with the LIMS are not Mobile	-34.34
Computers that interface with the LIMS can be Mobile	34.34
When evidence is transferred within the laboratory, Chain of Custody information is manually entered into a form on the computer	-67.35
When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes	55.85
When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer using a scan of a radio frequency identification (RFID) tag/label.	11.50
The LIMS allows analysts to create or access Summary Statistics showing their performance, backlog, and other case information	55.63
The LIMS does not allow analysts to create or access Summary Statistics showing their performance, backlog, and other case information	-55.63
The LIMS only identifies the current Status and location of evidence items	-38.02
The LIMS identifies not only the current Status and location of evidence items but also provides information about analyst assignments, sequence of analyses, and deadlines and priorities.	38.02
The LIMS provides no automation for analyst Report Preparation	-79.02
The LIMS provides templates for analyst Report Preparation	18.87
The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.	60.16
The LIMS supports new or ad hoc Query creation using menus	11.28
The LIMS supports new or ad hoc Query creation using commands and open ended query statements	20.91
The LIMS only supports predefined Queries	-32.19
The LIMS supports Case Prioritization using several criteria	39.97
The LIMS Prioritizes Cases using one or a few criteria	8.62
The LIMS does not support Case Prioritization	-48.58

The LIMS does not facilitate a supervisor Assigning Cases to Analysts	-36.31
The LIMS facilitates a supervisor Assigning Cases to Analysts	36.31

Average Utility Values: Aggregate (cont.)

The LIMS allows personnel to track the status of Equipment and Supplies	22.70
The LIMS does not allow personnel to track the status of Equipment and Supplies	-22.70
The LIMS keeps track of Personnel Certifications and certification dates	22.16
The LIMS does not keep track of Personnel Certifications and certification dates	-22.16
The LIMS allows Daughter Evidence items to be created as a new piece of evidence in a case WITHOUT clear links to parent evidence items nor the case	-74.05
The LIMS allows Daughter Evidence items to be created as a new piece of evidence in a case WITH clear links to parent evidence items and the case	74.05
The LIMS can interface with the Court System to track court dates and the status of pending cases	42.52
The LIMS cannot interface with the Court System to track court dates and the status of pending cases	-42.52
The LIMS can Interface directly with Analytical Equipment and be used to automatically collect and manage analytical data	26.52
The LIMS cannot Interface directly with Analytical Equipment or be used to automatically collect and manage analytical data	-26.52

Average Importances

	Total
Pre-logging	6.07
Data Entry	6.01
System Command Navigation	6.50
Screen Manipulation	5.18
Case Grouping	5.08
Terminal Mobility	4.13
Chain of Custody Transfer	8.00
Generation of Analyst Summary Statistics	6.19
Case Evidence Status	5.15
Management and Analyst Report Preparation	8.31
Query Access to Management Data	4.77
Case Prioritization	5.51
Analyst Assignment	4.12
Asset Management	3.34
Personnel Certification Management	3.26
Daughter evidence	8.82
Court system status	5.13
Interface with analytical equipment	4.43

Conjoint Analysis: *LabSize*

Average Utility Values: LabSize

	Small Size (<30)	Medium Size (30-100)	Large Size (>100)
The LIMS supports Pre-Logging by integrating with Agency Evidence Management Systems for initial data input	34.78	24.16	41.53
The LIMS supports the importation of Pre-Logged Data	28.87	22.12	27.12
The LIMS does not support importation of Pre-Logged Data	-63.64	-46.28	-68.65
Data about cases and evidence without any form of Data Entry automation	-53.24	-41.22	-61.87
Data about cases and evidence with some form of Data Entry automation	23.01	13.61	24.06
Data about cases and evidence with a high level of Data Entry automation	30.23	27.61	37.81
The LIMS only supports typed commands for Navigation	-53.59	-45.22	-60.32
The LIMS supports GUI for Navigation	-18.15	-10.23	13.50
The LIMS supports both typed commands as well as a GUI for Navigation	29.41	19.99	13.55
The LIMS supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation	42.33	35.46	33.28
Only one Screen can be opened at a time	-40.75	-52.33	-40.02
Multiple Screens can be open simultaneously	40.75	52.33	40.02
Cases can be grouped based on the submitting agency	54.63	41.49	34.02
Cases cannot be grouped based on the submitting agency	-54.63	-41.49	-34.02
Computers that interface with the LIMS are not Mobile	-36.26	-33.19	-35.11
Computers that interface with the LIMS can be Mobile	36.26	33.19	35.11
When evidence is transferred within the laboratory, Chain of Custody information is manually entered into a form on the computer	-75.14	-61.11	-73.09
When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes	63.55	54.69	53.13
When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer using a scan of a radio frequency identification (RFID) tag/label.	11.59	6.42	19.96
Average Importances by LabSize	52.53	54.37	59.62
The LIMS does not allow analysts to create or access Summary Statistics showing their performance, backlog, and other case information	-52.53	-54.37	-59.62
The LIMS only identifies the current Status and location of evidence items	-29.52	-36.78	-45.25
The LIMS identifies not only the current Status and location of evidence items but also provides information about analyst assignments, sequence of analyses, and deadlines and priorities.	29.52	36.78	45.25
The LIMS provides no automation for analyst Report Preparation	-77.19	-78.55	-80.92
The LIMS provides templates for analyst Report Preparation	19.56	16.88	21.77
The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.	57.63	61.67	59.15
The LIMS supports new or ad hoc Query creation using menus	29.33	6.20	8.86
The LIMS supports new or ad hoc Query creation using commands and	10.25	25.50	19.67

open ended query statements			
The LIMS only supports predefined Queries	-39.57	-31.71	-28.52

Average Utility Values: LabSize *(cont.)*

The LIMS supports Case Prioritization using several criteria	45.95	40.48	35.47
The LIMS Prioritizes Cases using one or a few criteria	0.76	12.92	6.17
The LIMS does not support Case Prioritization	-46.70	-53.40	-41.64
The LIMS does not facilitate a supervisor Assigning Cases to Analysts	-30.99	-33.31	-44.58
The LIMS facilitates a supervisor Assigning Cases to Analysts	30.99	33.31	44.58
The LIMS allows personnel to track the status of Equipment and Supplies	9.16	28.42	21.33
The LIMS does not allow personnel to track the status of Equipment and Supplies	-9.16	-28.42	-21.33
The LIMS keeps track of Personnel Certifications and certification dates	14.92	23.92	23.59
The LIMS does not keep track of Personnel Certifications and certification dates	-14.92	-23.92	-23.59
The LIMS allows Daughter Evidence items to be created as a new piece of evidence in a case WITHOUT clear links to parent evidence items nor the case	-99.40	-60.24	-81.84
The LIMS allows Daughter Evidence items to be created as a new piece of evidence in a case WITH clear links to parent evidence items and the case	99.40	60.24	81.84
The LIMS can interface with the Court System to track court dates and the status of pending cases	45.73	40.90	43.29
The LIMS cannot interface with the Court System to track court dates and the status of pending cases	-45.73	-40.90	-43.29
The LIMS can Interface directly with Analytical Equipment and be used to automatically collect and manage analytical data	14.80	27.65	31.72
The LIMS cannot Interface directly with Analytical Equipment or be used to automatically collect and manage analytical data	-14.80	-27.65	-31.72

Average Importances by LabSize

	Small Size (<30)	Medium Size (30-100)	Large Size (>100)
Pre-logging	6.74	5.36	6.84
Data Entry	5.35	5.84	6.70
System Command Navigation	6.40	6.36	6.80
Screen Manipulation	4.56	5.82	4.48
Case Grouping	6.33	5.15	4.20
Terminal Mobility	4.03	4.29	3.94
Chain of Custody Transfer	8.50	7.60	8.38
Generation of Analyst Summary Statistics	5.84	6.05	6.62
Case Evidence Status	3.79	5.49	5.41
Management and Analyst Report Preparation	7.83	8.54	8.21
Query Access to Management Data	5.93	4.72	4.15
Case Prioritization	5.66	5.88	4.80
Analyst Assignment	3.87	3.70	4.97
Asset Management	2.22	3.93	3.03
Personnel Certification Management	2.60	3.61	3.08

Daughter evidence	11.04	7.86	9.09
Court system status	5.65	4.76	5.44
Interface with analytical equipment	3.66	5.05	3.85

Conjoint Analysis: Personnel Level

Average Utility Values: Personnel Level

	Evidence Tech	Analyst	Management
The LIMS supports Pre-Logging by integrating with Agency Evidence Management Systems for initial data input	36.11	36.49	13.85
The LIMS supports the importation of Pre-Logged Data	30.34	27.56	12.03
The LIMS does not support importation of Pre-Logged Data	-66.44	-64.04	-25.88
Data about cases and evidence without any form of Data Entry automation	-61.66	-46.90	-42.46
Data about cases and evidence with some form of Data Entry automation	21.60	16.59	19.79
Data about cases and evidence with a high level of Data Entry automation	40.06	30.31	22.67
The LIMS only supports typed commands for Navigation	-59.09	-55.90	-38.18
The LIMS supports GUI for Navigation	-2.85	-3.23	-3.04
The LIMS supports both typed commands as well as a GUI for Navigation	21.88	21.72	11.35
The LIMS supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation	40.06	37.41	29.87
Only one Screen can be opened at a time	-50.95	-43.06	-52.05
Multiple Screens can be open simultaneously	50.95	43.06	52.05
Cases can be grouped based on the submitting agency	55.69	36.23	38.47
Cases cannot be grouped based on the submitting agency	-55.69	-36.23	-38.47
Computers that interface with the LIMS are not Mobile	-30.44	-34.68	-41.37
Computers that interface with the LIMS can be Mobile	30.44	34.68	41.37
When evidence is transferred within the laboratory, Chain of Custody information is manually entered into a form on the computer	-61.59	-67.26	-73.68
When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes	55.93	52.27	60.39
When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer using a scan of a radio frequency identification (RFID) tag/label.	5.66	14.99	13.29
The LIMS allows analysts to create or access Summary Statistics showing their performance, backlog, and other case information	54.96	55.04	59.05
The LIMS does not allow analysts to create or access Summary Statistics showing their performance, backlog, and other case information	-54.96	-55.04	-59.05
The LIMS only identifies the current Status and location of evidence items	-34.21	-37.08	-50.73
The LIMS identifies not only the current Status and location of evidence items but also provides information about analyst assignments, sequence of analyses, and deadlines and priorities.	34.21	37.08	50.73
The LIMS provides no automation for analyst Report Preparation	-72.16	-88.30	-62.92
The LIMS provides templates for analyst Report Preparation	24.88	18.48	9.95
The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.	47.29	69.82	52.97
The LIMS supports new or ad hoc Query creation using menus	18.04	12.32	4.03
The LIMS supports new or ad hoc Query creation using commands and	27.88	16.68	21.92

open ended query statements			
The LIMS only supports predefined Queries	-45.92	-29.01	-25.94

Average Utility Values: Personnel Level (cont.)

The LIMS supports Case Prioritization using several criteria	33.17	43.18	41.70
The LIMS Prioritizes Cases using one or a few criteria	10.13	7.05	8.75
The LIMS does not support Case Prioritization	-43.29	-50.23	-50.45
The LIMS does not facilitate a supervisor Assigning Cases to Analysts	-38.79	-33.83	-42.32
The LIMS facilitates a supervisor Assigning Cases to Analysts	38.79	33.83	42.32
The LIMS allows personnel to track the status of Equipment and Supplies	27.59	18.63	30.60
The LIMS does not allow personnel to track the status of Equipment and Supplies	-27.59	-18.63	-30.60
The LIMS keeps track of Personnel Certifications and certification dates	19.11	18.12	33.72
The LIMS does not keep track of Personnel Certifications and certification dates	-19.11	-18.12	-33.72
The LIMS allows Daughter Evidence items to be created as a new piece of evidence in a case WITHOUT clear links to parent evidence items nor the case	-83.14	-80.52	-44.81
The LIMS allows Daughter Evidence items to be created as a new piece of evidence in a case WITH clear links to parent evidence items and the case	83.14	80.52	44.81
The LIMS can interface with the Court System to track court dates and the status of pending cases	29.90	45.50	49.71
The LIMS cannot interface with the Court System to track court dates and the status of pending cases	-29.90	-45.50	-49.71
The LIMS can Interface directly with Analytical Equipment and be used to automatically collect and manage analytical data	25.08	25.21	33.24
The LIMS cannot Interface directly with Analytical Equipment or be used to automatically collect and manage analytical data	-25.08	-25.21	-33.24

Average Importances by Personnel Level

	Evidence Tech	Analyst	Management
Pre-logging	6.95	6.55	3.87
Data Entry	6.59	5.96	5.48
System Command Navigation	6.45	6.93	4.96
Screen Manipulation	5.66	4.82	5.78
Case Grouping	6.19	4.65	4.81
Terminal Mobility	3.82	4.11	4.65
Chain of Custody Transfer	7.88	7.80	8.44
Generation of Analyst Summary Statistics	6.11	6.13	6.56
Case Evidence Status	3.80	5.25	6.45
Management and Analyst Report Preparation	7.20	9.13	7.43
Query Access to Management Data	5.79	4.49	4.21
Case Prioritization	4.83	5.91	5.20
Analyst Assignment	4.31	3.91	4.70
Asset Management	3.92	2.86	4.08
Personnel Certification Management	3.05	2.64	4.93
Daughter evidence	9.24	8.95	8.01

Court system status	4.12	5.45	5.52
Interface with analytical equipment	4.11	4.48	4.89

Conjoint Analysis: *LIMS Vendor/Source*

Average Utility Values: LIMS Vendor/Source

	In House	External Vendor	Unknown
The LIMS supports Pre-Logging by integrating with Agency Evidence Management Systems for initial data input	38.00	26.01	20.66
The LIMS supports the importation of Pre-Logged Data	28.00	22.18	20.52
The LIMS does not support importation of Pre-Logged Data	-66.00	-48.19	-41.18
Data about cases and evidence without any form of Data Entry automation	-57.56	-45.28	-27.36
Data about cases and evidence with some form of Data Entry automation	23.32	16.29	2.44
Data about cases and evidence with a high level of Data Entry automation	34.24	28.98	24.92
The LIMS only supports typed commands for Navigation	-57.67	-45.56	-44.17
The LIMS supports GUI for Navigation	0.12	-11.95	6.12
The LIMS supports both typed commands as well as a GUI for Navigation	23.55	22.02	-12.46
The LIMS supports keystroke shortcuts for Navigation as well as typed commands and GUI for Navigation	34.00	35.49	50.51
Only one Screen can be opened at a time	-42.05	-53.80	-35.34
Multiple Screens can be open simultaneously	42.05	53.80	35.34
Cases can be grouped based on the submitting agency	41.76	40.75	45.36
Cases cannot be grouped based on the submitting agency	-41.76	-40.75	-45.36
Computers that interface with the LIMS are not Mobile	-36.66	-29.72	-43.85
Computers that interface with the LIMS can be Mobile	36.66	29.72	43.85
When evidence is transferred within the laboratory, Chain of Custody information is manually entered into a form on the computer	-69.14	-63.41	-76.43
When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer by scanning bar codes	51.30	55.68	82.29
When evidence is transferred within the laboratory, Chain of Custody information is automatically entered into the computer using a scan of a radio frequency identification (RFID) tag/label.	17.84	7.73	-5.86
The LIMS allows analysts to create or access Summary Statistics showing their performance, backlog, and other case information	57.16	52.92	60.21
The LIMS does not allow analysts to create or access Summary Statistics showing their performance, backlog, and other case information	-57.16	-52.92	-60.21
The LIMS only identifies the current Status and location of evidence items	-37.20	-37.05	-47.32
The LIMS identifies not only the current Status and location of evidence items but also provides information about analyst assignments, sequence of analyses, and deadlines and priorities.	37.20	37.05	47.32
The LIMS provides no automation for analyst Report Preparation	-83.77	-79.44	-50.25
The LIMS provides templates for analyst Report Preparation	24.21	16.87	-1.44
The LIMS provides templates for analyst Report Preparation and provides automatic field entry through drop-down boxes and automatic word/phrase completion.	59.57	62.57	51.69
The LIMS supports new or ad hoc Query creation using menus	13.34	4.24	34.06
The LIMS supports new or ad hoc Query creation using commands and open ended query statements	18.49	29.76	-8.63
The LIMS only supports predefined Queries	-31.84	-33.99	-25.43
The LIMS allows personnel to track the status of Equipment and Supplies	38.14	38.53	57.25

The LIMS Prioritizes Cases using one or a few criteria	8.39	12.54	-9.19
The LIMS does not support Case Prioritization	-46.53	-51.06	-48.06

Average Utility Values: LIMS Vendor/Source (cont.)

The LIMS does not facilitate a supervisor Assigning Cases to Analysts	-37.32	-32.45	-49.51
The LIMS facilitates a supervisor Assigning Cases to Analysts	37.32	32.45	49.51
The LIMS allows personnel to track the status of Equipment and Supplies	17.83	26.55	31.40
The LIMS does not allow personnel to track the status of Equipment and Supplies	-17.83	-26.55	-31.40
The LIMS keeps track of Personnel Certifications and certification dates	17.42	22.52	47.04
The LIMS does not keep track of Personnel Certifications and certification dates	-17.42	-22.52	-47.04
The LIMS allows Daughter Evidence items to be created as a new piece of evidence in a case WITHOUT clear links to parent evidence items nor the case	-88.33	-60.03	-62.11
The LIMS allows Daughter Evidence items to be created as a new piece of evidence in a case WITH clear links to parent evidence items and the case	88.33	60.03	62.11
The LIMS can interface with the Court System to track court dates and the status of pending cases	44.19	39.19	49.32
The LIMS cannot interface with the Court System to track court dates and the status of pending cases	-44.19	-39.19	-49.32
The LIMS can Interface directly with Analytical Equipment and be used to automatically collect and manage analytical data	25.81	23.74	44.00
The LIMS cannot Interface directly with Analytical Equipment or be used to automatically collect and manage analytical data	-25.81	-23.74	-44.00

Average Importances by LIMS Vendor/Source

	In House	External Vendor	Unknown
Pre-logging	6.63	5.53	5.52
Data Entry	6.50	5.94	3.63
System Command Navigation	6.37	6.55	6.97
Screen Manipulation	4.70	5.98	3.93
Case Grouping	5.00	5.17	5.04
Terminal Mobility	4.09	4.02	4.87
Chain of Custody Transfer	7.92	7.87	9.12
Generation of Analyst Summary Statistics	6.35	5.90	6.69
Case Evidence Status	4.68	5.67	5.26
Management and Analyst Report Preparation	8.32	8.74	6.09
Query Access to Management Data	4.73	4.79	4.92
Case Prioritization	5.19	5.68	6.47
Analyst Assignment	4.32	3.61	5.50
Asset Management	2.93	3.79	3.49
Personnel Certification Management	2.66	3.56	5.23
Daughter evidence	9.81	8.07	6.90
Court system status	5.52	4.62	5.48
Interface with analytical equipment	4.27	4.52	4.89

APPENDIX G – RESEARCH SOLICITATION LETTER

Mr/s/Dr. XXXXXX:
X State Laboratory Director

Dir Lab Director,

We are conducting a survey to identify the attitudes of forensics laboratory personnel about Laboratory Information Management Systems (LIMS) in managing evidence in forensics laboratories. We are conducting this survey in conjunction with the Midwest Forensics Resources Center (MFRC) under grant funding provided by the National Institute of Justice (NIJ).

The goal of the survey is to develop an understanding of the factors that will be influential in successfully selecting, implementing, and managing LIMS in forensics laboratories. This will be used in conjunction with data collected by the researchers during several site visits made to forensics laboratories. Results from this developmental research will be disseminated to forensic laboratories through newsletter publications, whitepapers posted on websites, and journal publications. Only aggregated results will be made public, with no reference made to specific laboratories or individuals.

As a Director of your crime laboratory, we request that you disseminate the survey to your laboratory personnel and offer them the opportunity to complete the survey. The survey is online and can be found at http://www.bus.iastate.edu/misresearch/lims/. The survey takes a considerable amount of time to complete (approximately 30-45 minutes); however, it is a critical component of the research project and will help to quantify the factors that will influence successful use of LIMS. The participation of key laboratory personnel is crucial to the success of this research and the utility of the results.

We appreciate your attention to this message. Please recognize that participation in this survey is completely voluntary. However, we would appreciate input from your laboratory personnel since it will greatly assist with future development of successful LIMS in forensics laboratories.

Ideally, we would like to have participants complete the survey within the next 2 weeks; therefore, if you would ask your laboratory personnel to complete the survey by September 21, this would be most helpful.

If you have any questions about this message, the survey, or any other facet of the research please do not hesitate to contact any of the researchers.

Sincerely,

Brian Mennecke (Mennecke@iastate.edu)
Anthony Townsend (amt@iastate.edu)
Anthony Hendrickson (AnthonyHendrickson@creighton.edu)
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