Project FORESIGHT Annual Report, 2016-2017

Forensic Science Initiative, College of Business & Economics, West Virginia University

FORESIGHT Laboratory Participant—Example (US$)

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FORESIGHT Benchmark Data 2016-2017

Project FORESIGHT is a business-guided self-evaluation of forensic science laboratories across the globe. The participating laboratories represent local, regional, state, and national agencies. Economics, accounting, finance, and forensic faculty provide assistance, guidance, and analysis. Laboratories participating in Project FORESIGHT have developed standardized definitions for metrics to evaluate work processes, linking financial information to work tasks, and functions. Laboratory managers can then assess resource allocations, efficiencies, and value of services—the mission of Project FORESIGHT is to measure, preserve what works, and change what does not.

The benchmark data for the 2016-2017 performance period includes laboratory submissions for a variety of fiscal year definitions. However, all submissions have December 31, 2016 as part of their fiscal year accounting. The majority of submissions follow a July 1, 2016 through June 30, 2017 convention. Others follow a year that begins as early as January 1, 2016 (ending December 31, 2016) while the other extreme includes laboratories with a fiscal year originating October 1, 2016 and ending September 30, 2017.

Consider the summary statistics for several of the key performance indicators. Because of outliers in several of the investigative areas, the most meaningful comparisons might best be made with respect to median as a representation of "typical" laboratory performance. To lend perspective to the spread of these metrics, each of the quartile metrics are reported along with the specific comparison to the laboratory highlighted in this report.

As of this writing, one hundred thirty-nine laboratory systems have contributed data to the project. For most areas of investigation, the submitted data offers a large enough sample to elicit good statistical properties. However, for Digital Evidence, Evidence Screening & Processing, and Forensic Pathology, the number of reporting laboratories in these areas is small and fewer inferences may be drawn from the data.

For more information on Project FORESIGHT, visit the Project web site at www.be.wvu.edu/forensic/foresight.htm. Questions regarding this report or other matters pertaining to Project FORESIGHT should be directed to the Principal Investigator Paul Speaker (paul.speaker@mail.wvu.edu).

FORESIGHT 20/20

The American Society of Crime Laboratory Directors (ASCLD) was successful in securing a grant from the Laura and John Arnold Foundation (LJAF) to assist laboratories in the extraction of data from their Laboratory Information Management Systems (LIMS),

including data for submission to Project FORESIGHT. The executive summary of FORESIGHT 20/20 project follows.

FORESIGHT 20/20 Executive Summary

The proliferation of television shows featuring CSI titles has both glamorized and cursed crime laboratories in America as expectations of laboratory performance have dramatically increased the demand for forensic science services. This increase in demand, coupled with laboratory funding cuts from the Great Recession, has created a bottleneck in the justice system as laboratory backlogs have risen, slowing down the entire system. The National Institute of Justice (NIJ) recognized this problem and funded a solution via two grants for Project FORESIGHT for the years 2009 through 2015. The Project FORESIGHT team was tasked with studying the forensic science industry and developing business metrics for forensic laboratories that would enable them to gain efficiencies and become more cost effective, thus addressing the bottleneck in the justice system. While Project FORESIGHT has had a pronounced effect on the participating laboratories, less than 20% of U.S. laboratories submit data to the project. The main reason for the lack of participation has been the difficulty in extracting the necessary data on laboratory casework and coupling that information with laboratory expenditures and personnel detail, which come from separate information management systems.

This proposal seeks funding to overcome this participation hurdle through the creation of software that provides the interface between the testing and casework information maintained in a Laboratory Information Management System (LIMS) and the separate financial and personnel systems. This software will be developed under ASCLD's leadership to connect the NIJ's FORESIGHT measurement standards with laboratories nationwide to permit broader forensic science industry perspectives and to enhance the business metrics available to individual laboratory directors for daily decision-making. Organizing software development through the four major LIMS providers offers a permanent software solution to all crime laboratories for access to business metrics and does so at no cost to the individual laboratories. For laboratories participating in FORESIGHT, these business metrics have permitted dramatic increases in efficiency and saved hundreds of millions of dollars. Extending participation fivefold is expected to have similarly magnified gains. Once initiated across the leading LIMS providers, this offers a permanent, broad-based system for monitoring performance of the individual laboratory and details on the performance across all forensic science.

PROJECT DESCRIPTION

The American Society of Crime Laboratory Directors (ASCLD) is a nonprofit professional society of crime laboratory directors and forensic science managers dedicated to

providing excellence in forensic science through leadership and innovation. The purpose of the organization is to foster professional interests, assist the development of laboratory management principles and techniques; acquire, preserve and disseminate forensic based information; maintain and improve communications among crime laboratory directors; and to promote, encourage and maintain the highest standards of practice in the field. With this mandate, ASCLD proposed to the Laura and John Arnold Foundation an investment to dramatically increase the efficiency and effectiveness of crime laboratories nationwide through the creation of financial intelligence software.

With ever increasing demands for services and shrinking budgets, a crime laboratory must have a thorough understanding of their operations from a business perspective and a means to compare that performance to the standards of the "forensic science industry." The National Institute of Justice (NIJ) has led efforts to improve laboratory business practices through the creation of Project FORESIGHT. Project FORESIGHT is a performance benchmarking model that enables crime laboratories to perform an internal business assessment and external comparison by standardizing terminology and performance metrics across local, state, and federal laboratories.

The FORESIGHT Project began as a funding award from the National Institute of Justice to the West Virginia University Forensic Science Initiative to develop a system that would enable laboratories to understand and assess the relationship between their casework, personnel, and budgetary expenditures. Forensic laboratory managers use these functions to assess resource allocations, human capital development, drive efficiencies, and evaluate the value of services—the mission is to measure, preserve what works, and change what does not. FORESIGHT is intended to support significant and enduring systematic reforms in accountability and decision-making in public forensic laboratories.

Participation in FORESIGHT is free, voluntary, and open to forensic science laboratories worldwide. FORESIGHT has led to significant improvement at the individual laboratory level and for the forensic industry. Evaluation of efficiency and effectiveness of a crime laboratory was virtually impossible without a common industry language and corresponding performance benchmarks. Individual annual reports to contributing laboratories detail the laboratory's metrics with emphasis on productivity, risk management, analytical process, and economic market forces. These annual evaluations are equivalent to a consultant's report, highlighting performance over time and across the industry. Even though participation is costless, less than 20% of U.S. laboratories enroll in the project. This low participation is not a comment on value of the project; rather a product of the difficulty of data extraction from multiple computer systems. Casework data is extracted from the LIMS, while personnel data and expenditures are extracted from one or more computer systems of the laboratory's parent organization (generally, a policing organization). To bridge the firewalls protecting the data in each system, laboratory management must manually extract data from these multiple systems to report their performance to project FORESIGHT. For many laboratories, the

cost in time and resources is deemed too high to participate. NIJ recognizes this burden and their Forensic Science Technology Working Group Operation Requirements highlight the need for increased IT knowledge and software for management to improve productivity.

FORESIGHT has led to a macro view of the provision of forensic science services. The common measurements have permitted a review of fundamental economic hypotheses and the delivery of crime laboratory services for economic regions. The results have shown that individual laboratories are highly efficient in the provision of services, but rarely cost effective because of the reliance on political jurisdictions, rather than economic markets, for the provision of services.

Although many laboratories have adopted this program to guide their operations, a major obstacle for implementation has been the "hands on" time required by laboratory staff to manually gather and input the required data. This data is composed of both laboratory and financial metrics, each of which is stored in separate locations or in systems that do not communicate. This then requires significant time dedicated to downloading this information and transferring it to the FORESIGHT program. The FORESIGHT program is not integrated with any of the existing vendor LIMS systems. As the LIMS systems have evolved, their capabilities have advanced to allow a more detailed monitoring of evidence samples as they move through the laboratory system. The crime laboratory user can detect problems and/or issues with samples before a report is issued and provides for a greater transparency to the criminal justice system as to the analysis history and quality assurance of that item of evidence.

The development of such freeware then permits simple extraction and submission of FORESIGHT data. That allows 100% participation for all U.S. laboratories. Such a census, rather than the current voluntary sample, will benefit both the new participants as well as those laboratories currently in the program as a more complete picture of the forensic industry emerges. With the combination of casework, expenditures, and personnel data in a single database, the freeware will also permit easier reporting for federal grant purposes. For laboratory leadership, the freeware also permits the construction of a manager's data dashboard with up-to-the-minute productivity metrics. The American Society of Crime Laboratory Directors is requesting funding to support the development of freeware software, FORESIGHT 20/20, enabling the seamless data collection of core business metrics from Laboratory Information Management Systems (LIMS) commonly employed by laboratories. Once implemented into the major LIMS providers, this legacy program requires no expenditures for individual laboratories beyond the normal updating of their LIMS.

Cost Metrics

Cost per Case

The **cost** includes allocations for capital, wages & salary, benefits, overtime & temporary hires, chemicals, reagents, consumables, gases, travel, quality assurance and accreditation, subcontracting, service of instruments, advertisements, non-instrument repairs and maintenance, equipment leasing, utilities, telecommunications, overhead, and other expenses.

A **case** in an investigative area refers to a request from a crime laboratory customer that includes forensic investigation in that investigative area. Note that a customer request may lead to a case in multiple investigative areas.

Table 1: Cost per Case by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	$110	$177	$444
Crime Scene Investigation	$1,108	$3,796	$6,993
Digital evidence - Audio & Video	$896	$11,978	$32,934
DNA Casework	$1,306	$1,885	$3,295
DNA Database	$42	$103	$178
Document Examination	$3,928	$7,007	$10,773
Drugs - Controlled Substances	$301	$492	$671
Evidence Screening & Processing	$479	$1,873	$2,621
Explosives	$8,378	$16,064	$32,736
Fingerprints	$521	$884	$1,468
Fire analysis	$1,328	$2,717	$4,047
Firearms and Ballistics	$1,050	$1,880	$3,702
Forensic Pathology	$2,604	$4,566	$4,613
Gun Shot Residue (GSR)	$2,530	$3,535	$4,945
Marks and Impressions	$4,674	$7,786	$13,743
Serology/Biology	$997	$1,956	$3,458
Toxicology ante mortem (excluding BAC)	$583	$736	$1,209
Toxicology post mortem (excluding BAC)	$597	$903	$1,234
Trace Evidence	$3,198	$4,832	$8,507

Project FORESIGHT submissions have increased annually. Although laboratory participation is voluntary, the summary statistics have been relatively consistent across

time, particularly for areas of investigation that have large numbers of submissions. For those areas with fewer observations, there has been a fair amount of fluctuation, indicative of the smaller sample and the voluntary nature of the submissions. To illustrate the time series behaviour of the median performance, the following table provides a comparison of the cost/case over time after correcting for inflation. These measures are termed "real cost/case" where real refers to inflation-adjusted measures. Prior year's metrics have been converted to 2016-2017 prices.

Table 2: Real* Cost per Case across Time

Area of Investigation	2011 - 2012	2012 - 2013	2013 - 2014	2014 - 2015	2015 - 2016	2016 - 2017
Blood Alcohol	$149	$144	$157	$153	$173	$177
Crime Scene Investigation	$6,645	$6,381	$2,314	$3,905	$5,586	$3,796
Digital evidence - Audio & Video	$5,927	$8,141	$2,881	$3,193	$4,470	$11,978
DNA Casework	$2,146	$2,410	$1,868	$2,142	$1,872	$1,885
DNA Database	$66	$78	$101	$83	$104	$103
Document Examination	$4,789	$8,169	$3,261	$4,659	$4,839	$7,007
Drugs - Controlled Substances	$229	$331	$388	$374	$438	$492
Evidence Screening & Processing	$645	$2,001	$645	$1,361	$1,652	$1,873
Explosives	$6,395	$17,050	$8,700	$13,637	$16,744	$16,064
Fingerprints	$400	$637	$693	$935	$970	$884
Fire analysis	$1,175	$1,653	$2,597	$2,157	$2,599	$2,717
Firearms and Ballistics	$1,007	$874	$1,409	$2,373	$2,460	$1,880
Forensic Pathology	$4,043	$2,680	$2,470	$2,378	$2,819	$4,566
Gun Shot Residue (GSR)	$1,493	$2,730	$2,062	$2,895	$3,235	$3,535
Marks and Impressions	$4,900	$11,391	$3,708	$7,764	$8,754	$7,786
Serology/Biology	$726	$2,638	$816	$1,889	$2,075	$1,956
Toxicology ante mortem (excluding BAC)	$745	$606	$579	$666	$801	$736
Toxicology post mortem (excluding BAC)	$782	$778	$1,013	$790	$951	$903
Trace Evidence	$3,493	$4,845	$5,896	$4,415	$5,100	$4,832
*2016-2017 = 100						

Cost per Item

Differences in case detail and differences in case complexity across laboratories (and across time) suggest that other relative cost measures may offer more meaningful

comparison. FORESIGHT data collection includes measures for items, samples, and tests in each investigative area.

An **item** refers to a single object for examination submitted to the laboratory. Note that one item may be investigated and counted in several investigation areas. As noted above, the **cost** includes allocations for capital, wages & salary, benefits, overtime & temporary hires, chemicals, reagents, consumables, gases, travel, quality assurance and accreditation, subcontracting, service of instruments, advertisements, non-instrument repairs and maintenance, equipment leasing, utilities, telecommunications, overhead, and other expenses.

Table 3: Cost per Item by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	$107	$165	$378
Crime Scene Investigation	$185	$682	$4,043
Digital evidence - Audio & Video	$381	$6,437	$32,073
DNA Casework	$441	$637	$1,154
DNA Database	$48	$106	$169
Document Examination	$889	$1,429	$3,362
Drugs - Controlled Substances	$136	$272	$410
Evidence Screening & Processing	$94	$732	$994
Explosives	$3,618	$9,659	$11,914
Fingerprints	$186	$366	$694
Fire analysis	$541	$885	$1,683
Firearms and Ballistics	$405	$736	$1,377
Forensic Pathology	$2,649	$3,691	$4,797
Gun Shot Residue (GSR)	$1,044	$1,503	$2,042
Marks and Impressions	$1,494	$3,593	$5,579
Serology/Biology	$242	$640	$994
Toxicology ante mortem (excluding BAC)	$482	$583	$812
Toxicology post mortem (excluding BAC)	$200	$466	$611
Trace Evidence	$1,132	$2,175	$4,408

Cost per Sample

A **sample** refers to an item of evidence or a portion of an item of evidence that generates a reported result.

As noted above, the **cost** includes allocations for capital, wages & salary, benefits, overtime & temporary hires, chemicals, reagents, consumables, gases, travel, quality assurance and accreditation, subcontracting, service of instruments, advertisements, non-instrument repairs and maintenance, equipment leasing, utilities, telecommunications, overhead, and other expenses.

The sample offers a consistently applied metric across laboratories and suggests an average cost measure that is intuitively comparable in cross sectional commentary.

Table 4: Cost per Sample by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	$91	$133	$281
Crime Scene Investigation	$8	$30	$254
Digital evidence - Audio & Video	$69	$456	$7,490
DNA Casework	$295	$415	$695
DNA Database	$29	$105	$109
Document Examination	$714	$1,033	$1,788
Drugs - Controlled Substances	$82	$157	$365
Evidence Screening & Processing	$67	$168	$441
Explosives	$1,728	$2,650	$4,274
Fingerprints	$110	$188	$421
Fire analysis	$248	$445	$1,196
Firearms and Ballistics	$363	$555	$891
Forensic Pathology	$2,659	$3,050	$3,839
Gun Shot Residue (GSR)	$285	$417	$967
Marks and Impressions	$479	$1,432	$4,717
Serology/Biology	$108	$148	$392
Toxicology ante mortem (excluding BAC)	$216	$350	$527
Toxicology post mortem (excluding BAC)	$134	$263	$450
Trace Evidence	$539	$1,440	$2,411

Cost per Test

A **test** refers to an analytical process, including but not limited to visual examination, instrumental analysis, presumptive evaluations, enhancement techniques, extractions, quantifications, microscopic techniques, and comparative examinations. This does not include technical or administrative reviews.

As noted above, the **cost** includes allocations for capital, wages & salary, benefits, overtime & temporary hires, chemicals, reagents, consumables, gases, travel, quality assurance and accreditation, subcontracting, service of instruments, advertisements, non-instrument repairs and maintenance, equipment leasing, utilities, telecommunications, overhead, and other expenses.

Table 5: Cost per Test by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	$52	$86	$159
Crime Scene Investigation	N/A	N/A	N/A
Digital evidence - Audio & Video	$296	$1,421	$2,705
DNA Casework	$65	$93	$158
DNA Database	$25	$68	$108
Document Examination	$179	$754	$1,564
Drugs - Controlled Substances	$48	$70	$132
Evidence Screening & Processing	$44	$102	$235
Explosives	$783	$1,141	$1,591
Fingerprints	$75	$110	$174
Fire analysis	$207	$432	$803
Firearms and Ballistics	$111	$240	$557
Forensic Pathology	$1,006	$2,587	$2,607
Gun Shot Residue (GSR)	$280	$487	$765
Marks and Impressions	$362	$1,117	$2,191
Serology/Biology	$79	$141	$212
Toxicology ante mortem (excluding BAC)	$76	$107	$165
Toxicology post mortem (excluding BAC)	$53	$92	$137
Trace Evidence	$182	$490	$889

Cost per Report

A **report** refers to a formal statement of the results of an investigation, or of any matter on which definite information is required, made by some person or body instructed or required to do so.

As noted above, the **cost** includes allocations for capital, wages & salary, benefits, overtime & temporary hires, chemicals, reagents, consumables, gases, travel, quality assurance and accreditation, subcontracting, service of instruments, advertisements, non-instrument repairs and maintenance, equipment leasing, utilities, telecommunications, overhead, and other expenses.

Table 6: Cost per Report by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	$108	$167	$463
Crime Scene Investigation	$808	$1,081	$5,354
Digital evidence - Audio & Video	$1,228	$12,215	$21,294
DNA Casework	$1,269	$1,755	$3,058
DNA Database	$36	$109	$170
Document Examination	$3,398	$3,981	$5,784
Drugs - Controlled Substances	$233	$299	$425
Evidence Screening & Processing	$427	$638	$715
Explosives	$4,038	$4,631	$18,378
Fingerprints	$307	$585	$1,170
Fire analysis	$1,239	$1,654	$3,287
Firearms and Ballistics	$1,058	$2,004	$3,428
Forensic Pathology	$2,700	$2,927	$3,650
Gun Shot Residue (GSR)	$1,051	$1,282	$3,667
Marks and Impressions	$3,908	$4,772	$8,756
Serology/Biology	$610	$745	$1,484
Toxicology ante mortem (excluding BAC)	$514	$630	$896
Toxicology post mortem (excluding BAC)	$550	$720	$1,011
Trace Evidence	$2,890	$4,171	$5,539

Metric Interpretation

The various unit cost metrics may be interpreted using the technique highlighted in The Decomposition of Return on Investment for Forensic Laboratories, *Forensic Science Policy & Management: An International Journal* Volume 1, Issue 2, 2009, Paul J. Speaker, pages 96-102. Consider the Cost/Case metric which may be decomposed into:

$$\frac{Cost}{Case} = \frac{Average\ Compensation\ x\ Testing\ Intensity}{Personnel\ Productivity\ x\ Personnel\ Expense\ Ratio}$$

From the decomposition expression for the Cost/Case, an increase in the numerator components, Average Compensation or Testing (or Sampling) Intensity, will increase the cost per case. Similarly, a decrease in denominator component will increase the cost per case. This may occur from either a drop in productivity, as measured by cases processed per FTE, or from an increase in capital investment for future productivity but financed via a drop in personnel expenses relative to total expenses.

Although the metric breakdown illustrated above offers a decomposition of the Cost/Case metric, a similar procedure may be applied to other cost metrics. Likewise, the Testing Intensity metric may be replaced by a Sampling Intensity metric (e.g., Samples/Case) or similar decomposition which offers the most meaning to the individual laboratory.

Market Metrics

A substantial portion of the cost to the laboratory comes through personal services budget for salary and benefits. (The section below on Analytical Process Metrics highlights the percentage of total costs attributable to personnel expenditures.) Laboratories across the globe and across a particular country face very different labor markets and cost of living conditions. As such, accounting for the salary and benefit pressures in each market is beyond the direct control of the individual laboratory and is subject to the market forces in a laboratory's political jurisdiction.

It may be helpful for a laboratory to replace their specific average compensation with that of the reported sample median to gain insight into how they compare to other laboratories once market forces have been neutralized.

Average Compensation

Note that **compensation** includes all personnel expenditures. This includes wages, salary, and benefits operating staff, support staff, and administrative staff. Centrally assigned compensation is apportioned to each investigative area according to the percentage of full-time equivalent employees assigned to a particular investigative area.

Note that values reported in this table and other tables with budgetary metrics have been converted to the currency of the reporting laboratory using the exchange rate for December 31 of the measured year as reported at www.xe.com.

Table 7: Average Compensation by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	$89,494	$116,286	$137,656
Crime Scene Investigation	$91,121	$114,823	$144,175
Digital evidence - Audio & Video	$88,297	$108,615	$128,958
DNA Casework	$116,904	$135,472	$146,169
DNA Database	$82,741	$104,623	$121,991
Document Examination	$93,057	$108,530	$133,720
Drugs - Controlled Substances	$106,887	$118,798	$137,419
Evidence Screening & Processing	$71,784	$86,330	$125,878
Explosives	$100,526	$113,321	$126,518
Fingerprints	$89,262	$111,378	$131,486
Fire analysis	$89,406	$115,859	$135,580
Firearms and Ballistics	$99,271	$119,392	$134,260
Forensic Pathology	$139,368	$155,964	$158,349
Gun Shot Residue (GSR)	$91,217	$105,660	$124,497
Marks and Impressions	$91,989	$106,897	$129,003
Serology/Biology	$90,647	$99,613	$116,408
Toxicology ante mortem (excluding BAC)	$82,556	$91,208	$118,993
Toxicology post mortem (excluding BAC)	$86,465	$100,745	$113,340
Trace Evidence	$88,491	$105,295	$120,947

Risk Management Metrics

There are a variety of metrics that may be used in the decomposition of average cost to suggest quality and/or risk. Three of these metrics follow to highlight the level of testing, sampling, and items examined internally per case.

Items per Case

An **item** refers to a single object for examination submitted to the laboratory. Note that one item may be investigated and counted in several investigation areas.

A **case** in an investigative area refers to a request from a crime laboratory customer that includes forensic investigation in that investigative area. Note that a customer request may lead to a case in multiple investigative areas.

Table 8: Items per Case by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	0.95	1.02	1.24
Crime Scene Investigation	1.01	4.75	9.92
Digital evidence - Audio & Video	1.59	3.10	4.19
DNA Casework	2.78	2.95	3.13
DNA Database	0.97	1.00	1.00
Document Examination	2.79	3.62	5.67
Drugs - Controlled Substances	1.39	1.72	2.03
Evidence Screening & Processing	2.09	3.32	3.82
Explosives	1.50	1.86	4.94
Fingerprints	1.49	2.20	2.90
Fire analysis	2.14	2.52	3.24
Firearms and Ballistics	1.86	2.56	4.34
Forensic Pathology	0.88	0.93	0.98
Gun Shot Residue (GSR)	1.56	2.13	2.43
Marks and Impressions	1.90	3.03	3.84
Serology/Biology	2.91	3.66	4.68
Toxicology ante mortem (excluding BAC)	1.11	1.33	1.47
Toxicology post mortem (excluding BAC)	1.71	2.24	3.03
Trace Evidence	1.89	2.23	3.26

Samples per Case

A **sample** refers to an item of evidence or a portion of an item of evidence that generates a reported result.

A **case** in an investigative area refers to a request from a crime laboratory customer that includes forensic investigation in that investigative area. Note that a customer request may lead to a case in multiple investigative areas.

Table 9: Samples per Case by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	1.06	1.45	1.97
Crime Scene Investigation	5.02	15.35	119.52
Digital evidence - Audio & Video	1.73	3.91	6.57
DNA Casework	4.41	4.88	5.08
DNA Database	0.96	1.00	1.01
Document Examination	4.61	8.11	10.95
Drugs - Controlled Substances	1.79	2.80	4.10
Evidence Screening & Processing	3.58	5.55	14.50
Explosives	4.23	6.57	15.61
Fingerprints	2.53	4.64	5.68
Fire analysis	2.29	5.37	7.61
Firearms and Ballistics	2.20	3.97	6.99
Forensic Pathology	0.92	0.98	1.00
Gun Shot Residue (GSR)	2.46	5.59	9.50
Marks and Impressions	1.89	4.56	11.32
Serology/Biology	4.40	7.47	28.75
Toxicology ante mortem (excluding BAC)	1.25	1.97	2.51
Toxicology post mortem (excluding BAC)	1.71	3.79	4.67
Trace Evidence	2.07	4.16	6.25

Tests per Case

A **test** refers to an analytical process, including but not limited to visual examination, instrumental analysis, presumptive evaluations, enhancement techniques, extractions, quantifications, microscopic techniques, and comparative examinations. This does not include technical or administrative reviews.

A **case** in an investigative area refers to a request from a crime laboratory customer that includes forensic investigation in that investigative area. Note that a customer request may lead to a case in multiple investigative areas.

Table 10: Tests per Case by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	1.95	2.13	2.79
Crime Scene Investigation	67.47	122.78	170.65
Digital evidence - Audio & Video	5.29	7.84	30.51
DNA Casework	20.56	21.59	22.59
DNA Database	0.99	1.00	1.13
Document Examination	7.07	11.36	31.00
Drugs - Controlled Substances	4.65	5.50	8.84
Evidence Screening & Processing	9.02	9.85	23.51
Explosives	10.14	15.43	80.00
Fingerprints	5.20	6.66	11.30
Fire analysis	5.29	6.58	12.00
Firearms and Ballistics	3.71	7.90	17.44
Forensic Pathology	1.00	1.03	5.84
Gun Shot Residue (GSR)	4.54	6.17	7.60
Marks and Impressions	4.43	9.94	14.76
Serology/Biology	9.93	18.67	23.25
Toxicology ante mortem (excluding BAC)	4.31	7.72	9.64
Toxicology post mortem (excluding BAC)	7.13	11.04	13.59
Trace Evidence	8.87	10.87	18.48

Reports per Case

A **report** refers to a formal statement of the results of an investigation, or of any matter on which definite information is required, made by some person or body instructed or required to do so.

A **case** in an investigative area refers to a request from a crime laboratory customer that includes forensic investigation in that investigative area. Note that a customer request may lead to a case in multiple investigative areas.

Table 11: Reports per Case by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	0.94	1.02	1.07
Crime Scene Investigation	0.97	1.11	1.32
Digital evidence - Audio & Video	0.86	0.99	1.17
DNA Casework	0.99	1.02	1.05
DNA Database	0.99	1.01	1.07
Document Examination	1.00	1.20	2.55
Drugs - Controlled Substances	0.94	1.24	1.93
Evidence Screening & Processing	0.93	1.07	3.64
Explosives	1.00	1.26	4.08
Fingerprints	0.92	1.04	2.54
Fire analysis	0.97	1.13	1.61
Firearms and Ballistics	0.90	1.02	1.15
Forensic Pathology	0.96	1.01	1.08
Gun Shot Residue (GSR)	1.01	1.46	2.89
Marks and Impressions	0.92	1.23	2.64
Serology/Biology	0.92	1.14	5.44
Toxicology ante mortem (excluding BAC)	0.95	1.03	1.21
Toxicology post mortem (excluding BAC)	1.00	1.15	1.63
Trace Evidence	0.94	1.23	1.84

Samples per Item

A **sample** refers to an item of evidence or a portion of an item of evidence that generates a reported result.

An **item** refers to a single object for examination submitted to the laboratory. Note that one item may be investigated and counted in several investigation areas.

Table 12: Samples per Item examined internally by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	1.04	1.19	1.67
Crime Scene Investigation	1.02	1.07	1.58
Digital evidence - Audio & Video	0.90	1.11	3.21
DNA Casework	1.53	1.64	1.73
DNA Database	0.96	1.00	1.01
Document Examination	1.00	1.15	2.86
Drugs - Controlled Substances	1.00	1.37	2.20
Evidence Screening & Processing	1.09	1.94	2.60
Explosives	1.06	3.04	4.15
Fingerprints	1.24	1.81	2.53
Fire analysis	1.01	1.09	2.67
Firearms and Ballistics	1.00	1.21	2.02
Forensic Pathology	1.00	1.05	1.06
Gun Shot Residue (GSR)	1.09	2.83	4.33
Marks and Impressions	1.01	1.18	3.11
Serology/Biology	1.06	1.93	7.59
Toxicology ante mortem (excluding BAC)	1.03	1.35	1.80
Toxicology post mortem (excluding BAC)	1.02	1.38	2.14
Trace Evidence	1.07	1.90	2.21

Tests per Item

A **test** refers to an analytical process, including but not limited to visual examination, instrumental analysis, presumptive evaluations, enhancement techniques, extractions, quantifications, microscopic techniques, and comparative examinations. This does not include technical or administrative reviews.

An **item** refers to a single object for examination submitted to the laboratory. Note that one item may be investigated and counted in several investigation areas.

Table 13: Tests per Item examined internally by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	1.96	2.20	2.52
Crime Scene Investigation	5.08	8.48	16.80
Digital evidence - Audio & Video	1.11	2.18	21.74
DNA Casework	6.86	7.38	7.82
DNA Database	0.98	1.00	1.17
Document Examination	1.11	3.16	3.88
Drugs - Controlled Substances	2.29	3.02	5.10
Evidence Screening & Processing	2.26	2.96	7.93
Explosives	4.50	7.67	10.14
Fingerprints	2.19	3.11	4.17
Fire analysis	2.03	2.50	3.28
Firearms and Ballistics	1.29	2.28	6.10
Forensic Pathology	1.05	1.09	3.13
Gun Shot Residue (GSR)	2.36	3.03	3.60
Marks and Impressions	1.83	3.03	3.90
Serology/Biology	3.11	4.99	6.07
Toxicology ante mortem (excluding BAC)	3.12	5.34	7.07
Toxicology post mortem (excluding BAC)	3.13	4.79	5.81
Trace Evidence	4.06	5.26	6.44

Reports per Item

A **report** refers to a formal statement of the results of an investigation, or of any matter on which definite information is required, made by some person or body instructed or required to do so.

An **item** refers to a single object for examination submitted to the laboratory. Note that one item may be investigated and counted in several investigation areas.

Table 14: Reports per Item examined internally by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	0.80	1.00	1.09
Crime Scene Investigation	0.11	0.16	1.05
Digital evidence - Audio & Video	0.23	0.35	0.78
DNA Casework	0.33	0.35	0.37
DNA Database	0.97	1.00	1.03
Document Examination	0.15	0.47	0.91
Drugs - Controlled Substances	0.48	0.79	1.14
Evidence Screening & Processing	0.29	0.40	0.89
Explosives	0.40	1.00	2.39
Fingerprints	0.35	0.64	1.21
Fire analysis	0.36	0.49	0.63
Firearms and Ballistics	0.25	0.38	0.52
Forensic Pathology	1.06	1.13	1.17
Gun Shot Residue (GSR)	0.38	0.90	1.38
Marks and Impressions	0.20	0.74	1.08
Serology/Biology	0.17	0.39	1.42
Toxicology ante mortem (excluding BAC)	0.65	0.81	1.08
Toxicology post mortem (excluding BAC)	0.32	0.66	0.87
Trace Evidence	0.30	0.53	0.82

Tests per Sample

A **test** refers to an analytical process, including but not limited to visual examination, instrumental analysis, presumptive evaluations, enhancement techniques, extractions, quantifications, microscopic techniques, and comparative examinations. This does not include technical or administrative reviews.

A **sample** refers to an item of evidence or a portion of an item of evidence that generates a reported result.

Table 15: Tests per Sample by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	1.23	1.75	1.99
Crime Scene Investigation	1.00	1.03	5.61
Digital evidence - Audio & Video	1.00	1.36	4.38
DNA Casework	4.27	4.51	4.72
DNA Database	0.99	1.00	1.12
Document Examination	1.02	1.31	2.12
Drugs - Controlled Substances	1.25	2.30	3.11
Evidence Screening & Processing	0.69	1.31	3.99
Explosives	1.95	2.36	4.78
Fingerprints	1.15	1.40	2.99
Fire analysis	0.98	1.06	2.52
Firearms and Ballistics	1.01	1.57	2.93
Forensic Pathology	1.00	1.01	1.27
Gun Shot Residue (GSR)	0.70	1.00	2.05
Marks and Impressions	1.00	1.80	3.02
Serology/Biology	0.80	1.18	3.20
Toxicology ante mortem (excluding BAC)	1.72	3.38	4.32
Toxicology post mortem (excluding BAC)	1.70	2.79	3.42
Trace Evidence	2.13	2.66	4.03

Productivity Metrics

Return to the decomposition measure for the cost/case. The denominator terms have the opposite effect on average cost. That is, as ***labor productivity*** or the ***labor expense ratio*** increase, average costs will fall. This confirms that, as a representative scientist is able to process more cases per year, then the effect will be a decrease in the average cost as fixed expenditures are averaged over a higher volume of processed cases. Similarly, if a greater portion of the budget is devoted to personnel expenditures (as opposed to capital investment) *ceteris paribus*, more cases will be processed for the same expenditure at the opportunity cost of delaying investment in capital equipment for future returns.

The next five tables contain the LabRAT summary statistics for alternative personnel productivity ratio measures.

Cases per FTE

This measure is simply the number of Cases completed for each full-time equivalent (FTE) employee (the work input of a full-time employee working for one full year) retained by the laboratory. It gives an indication of the level of productivity within the average laboratory by investigative area.

Table 16: Cases per FTE by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	351	921	1,318
Crime Scene Investigation	16	80	167
Digital evidence - Audio & Video	5	16	50
DNA Casework	46	91	122
DNA Database	1,284	2,259	5,098
Document Examination	10	19	46
Drugs - Controlled Substances	292	380	524
Evidence Screening & Processing	48	66	142
Explosives	4	6	11
Fingerprints	109	149	256
Fire analysis	30	52	110
Firearms and Ballistics	50	70	168
Forensic Pathology	38	41	51
Gun Shot Residue (GSR)	22	35	62
Marks and Impressions	7	13	28
Serology/Biology	29	64	150
Toxicology ante mortem (excluding BAC)	107	169	257
Toxicology post mortem (excluding BAC)	78	119	207
Trace Evidence	16	22	40

Items per FTE

This measure is the number of Items examined internally for each full-time equivalent (FTE) employee (the work input of a full-time employee working for one full year) retained by the laboratory. It gives an indication of the level of productivity within the average laboratory by investigative area.

Table 17: Items examined internally per FTE by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	394	968	1,411
Crime Scene Investigation	27	174	856
Digital evidence - Audio & Video	14	79	258
DNA Casework	136	269	362
DNA Database	1,508	2,252	5,586
Document Examination	30	79	152
Drugs - Controlled Substances	425	624	1,000
Evidence Screening & Processing	134	180	449
Explosives	9	12	34
Fingerprints	219	350	576
Fire analysis	67	158	266
Firearms and Ballistics	141	254	390
Forensic Pathology	39	41	52
Gun Shot Residue (GSR)	52	78	133
Marks and Impressions	19	33	80
Serology/Biology	106	211	588
Toxicology ante mortem (excluding BAC)	168	227	275
Toxicology post mortem (excluding BAC)	178	222	388
Trace Evidence	36	49	118

Samples per FTE

This measure is the number of samples from Items examined internally for each full-time equivalent (FTE) employee (the work input of a full-time employee working for one full year) retained by the laboratory. It gives an indication of the level of productivity within the average laboratory by investigative area.

Table 18: Samples per FTE by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	654	1,288	1,781
Crime Scene Investigation	106	1,915	11,207
Digital evidence - Audio & Video	26	207	17,237
DNA Casework	238	452	557
DNA Database	1,513	2,658	5,651
Document Examination	76	106	208
Drugs - Controlled Substances	566	1,303	1,934
Evidence Screening & Processing	360	636	769
Explosives	15	41	70
Fingerprints	380	679	1,200
Fire analysis	108	203	493
Firearms and Ballistics	163	312	613
Forensic Pathology	46	57	67
Gun Shot Residue (GSR)	108	295	448
Marks and Impressions	26	79	202
Serology/Biology	335	780	1,240
Toxicology ante mortem (excluding BAC)	257	359	445
Toxicology post mortem (excluding BAC)	294	359	595
Trace Evidence	50	90	236

Tests per FTE

This measure is the number of tests performed on samples for each full-time equivalent (FTE) employee (the work input of a full-time employee working for one full year) retained by the laboratory. It gives an indication of the level of productivity within the average laboratory by investigative area.

Table 19: Tests per FTE by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	971	1,907	2,954
Crime Scene Investigation	2,551	8,997	13,204
Digital evidence - Audio & Video	53	121	485
DNA Casework	1,045	1,947	2,567
DNA Database	1,713	4,312	6,564
Document Examination	94	192	751
Drugs - Controlled Substances	1,419	2,194	4,607
Evidence Screening & Processing	449	1,517	3,502
Explosives	61	101	171
Fingerprints	783	1,230	2,012
Fire analysis	143	336	779
Firearms and Ballistics	325	770	1,459
Forensic Pathology	66	75	186
Gun Shot Residue (GSR)	140	253	479
Marks and Impressions	54	93	340
Serology/Biology	572	834	1,827
Toxicology ante mortem (excluding BAC)	826	1,261	1,741
Toxicology post mortem (excluding BAC)	847	1,114	1,864
Trace Evidence	150	242	588

Reports per FTE

This measure is the number of reports filed per full-time equivalent (FTE) employees (the work input of a full-time employee working for one full year) retained by the laboratory. It gives an indication of the level of productivity within the average laboratory by investigative area.

Table 20: Reports per FTE by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	399	941	1,378
Crime Scene Investigation	25	117	218
Digital evidence - Audio & Video	7	20	118
DNA Casework	57	94	125
DNA Database	1,286	1,929	5,182
Document Examination	23	27	37
Drugs - Controlled Substances	406	511	636
Evidence Screening & Processing	127	142	159
Explosives	8	25	32
Fingerprints	130	248	349
Fire analysis	42	70	107
Firearms and Ballistics	56	75	130
Forensic Pathology	46	55	63
Gun Shot Residue (GSR)	32	90	116
Marks and Impressions	14	23	27
Serology/Biology	90	146	164
Toxicology ante mortem (excluding BAC)	169	197	234
Toxicology post mortem (excluding BAC)	123	148	214
Trace Evidence	25	33	39

Analytical Process Metrics

The next decomposition measure, **Personnel Expense/Total Expense**, serves as a proxy for the level of analytical technology chosen. This measure has a significant negative correlation with **Capital Expense/Total Expense** and serves as simpler decomposition term for the return on investment.

Below, the cost structure is detailed with a breakdown of expenses in capital, labor, consumables, versus other costs. Investigative areas that are highly automated, such as evidenced by the DNA database processing line, should show a lower Personnel Expense/Total Expense.

Personnel Expense as a proportion of Total Expense

Note that **compensation** includes all personnel expenditures. This includes wages, salary, and benefits operating staff, support staff, and administrative staff. Centrally assigned compensation is apportioned to each investigative area according to the percentage of full-time equivalent employees assigned to a particular investigative area.

Table 21: Personnel Expenditures/Total Expenditures by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	74.77%	81.80%	86.72%
Crime Scene Investigation	77.35%	86.19%	90.64%
Digital evidence - Audio & Video	63.78%	85.21%	87.83%
DNA Casework	70.42%	82.60%	90.07%
DNA Database	49.43%	62.02%	75.14%
Document Examination	83.80%	89.25%	95.41%
Drugs - Controlled Substances	70.66%	79.13%	86.58%
Evidence Screening & Processing	73.61%	88.21%	93.49%
Explosives	75.63%	83.49%	90.46%
Fingerprints	76.05%	84.05%	89.21%
Fire analysis	73.73%	83.36%	89.90%
Firearms and Ballistics	69.25%	77.71%	82.88%
Forensic Pathology	78.11%	86.40%	91.25%
Gun Shot Residue (GSR)	77.18%	83.12%	89.73%
Marks and Impressions	81.97%	90.86%	95.69%
Serology/Biology	78.13%	85.58%	94.86%
Toxicology ante mortem (excluding BAC)	65.68%	72.75%	79.87%
Toxicology post mortem (excluding BAC)	70.43%	75.58%	82.21%
Trace Evidence	69.11%	76.80%	82.20%

Capital Expense as a proportion of Total Expense

Capital expenditures reference those purchases by the laboratory for assets whose use extends across time periods. Since depreciation classifications place laboratory equipment into a five-year depreciation class, the capital expenditures over a five year period are averaged in the determination of this portion of a laboratory's expenditures.

Table 22: Capital Expenditures/Total Expenditures by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	2.25%	4.02%	7.53%
Crime Scene Investigation	0.24%	3.83%	5.19%
Digital evidence - Audio & Video	1.49%	6.45%	15.40%
DNA Casework	1.92%	3.68%	7.51%
DNA Database	1.05%	4.00%	5.32%
Document Examination	0.36%	1.30%	3.66%
Drugs - Controlled Substances	3.46%	6.25%	12.07%
Evidence Screening & Processing	0.52%	2.68%	4.84%
Explosives	2.09%	3.76%	9.94%
Fingerprints	2.48%	3.83%	8.63%
Fire analysis	1.95%	3.42%	5.90%
Firearms and Ballistics	2.79%	5.10%	9.44%
Forensic Pathology	0.17%	1.45%	4.95%
Gun Shot Residue (GSR)	1.67%	4.31%	8.00%
Marks and Impressions	0.30%	1.60%	3.86%
Serology/Biology	0.72%	1.64%	4.36%
Toxicology ante mortem (excluding BAC)	3.25%	5.53%	10.92%
Toxicology post mortem (excluding BAC)	3.43%	5.53%	8.33%
Trace Evidence	5.44%	8.15%	14.06%

Consumables Expense as a proportion of Total Expense

This category includes a variety of variable cost components including chemicals, reagents, consumables, and gases.

Table 23: Consumables Expenditures/Total Expenditures by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	4.53%	5.28%	7.01%
Crime Scene Investigation	0.20%	1.14%	3.92%
Digital evidence - Audio & Video	0.00%	1.60%	3.18%
DNA Casework	3.77%	5.93%	9.15%
DNA Database	5.88%	9.04%	13.67%
Document Examination	0.23%	0.55%	1.69%
Drugs - Controlled Substances	2.63%	4.14%	7.76%
Evidence Screening & Processing	0.46%	1.19%	2.84%
Explosives	1.18%	1.97%	3.57%
Fingerprints	0.73%	1.59%	7.21%
Fire analysis	1.43%	2.69%	5.04%
Firearms and Ballistics	2.09%	6.09%	9.97%
Forensic Pathology	1.74%	2.10%	2.69%
Gun Shot Residue (GSR)	1.15%	2.27%	4.31%
Marks and Impressions	0.46%	1.31%	3.23%
Serology/Biology	1.31%	4.28%	8.99%
Toxicology ante mortem (excluding BAC)	5.52%	7.56%	10.06%
Toxicology post mortem (excluding BAC)	4.74%	5.90%	7.90%
Trace Evidence	1.83%	2.52%	6.58%

Turn-around Time

Note that turn-around time is offered in two forms. The first is a measure that begins when the last item of evidence in an investigative area has been submitted to the laboratory. The second measure begins the turn-around time count with the submission of the first piece of evidence in an investigative area. Because most laboratories only record one or the other of these measures, there is some seeming inconsistency which is attributed to the limited sample. The metric has been slightly altered from previous years to correspond to recommendations from Project FORESIGHT participants. The change in the metric reflects the time from each request for analysis to issuance of a report. As such, a case in one investigative area may have multiple turn-around times that correspond to separate requests.

Median Turn-around Time (Timed in days from last submission of evidence to Report submission)

Table 24: Turnaround Time from Last Item Received by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	8	13	24
Crime Scene Investigation	10	11	59
Digital evidence - Audio & Video	34	57	148
DNA Casework	57	66	77
DNA Database	31	80	82
Document Examination	36	40	55
Drugs - Controlled Substances	33	40	53
Evidence Screening & Processing	25	31	35
Explosives	29	36	50
Fingerprints	26	36	57
Fire analysis	26	40	55
Firearms and Ballistics	18	46	128
Forensic Pathology	40	72	90
Gun Shot Residue (GSR)	25	36	48
Marks and Impressions	33	47	60
Serology/Biology	26	37	47
Toxicology ante mortem (excluding BAC)	24	31	47
Toxicology post mortem (excluding BAC)	20	29	42
Trace Evidence	58	71	84

Median Turn-around Time (Timed in days from first submission of evidence to Report submission)

Table 25: Turnaround Time from First Item Received by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	8	14	29
Crime Scene Investigation	11	25	106
Digital evidence - Audio & Video	78	99	126
DNA Casework	81	117	156
DNA Database	42	49	58
Document Examination	41	58	76
Drugs - Controlled Substances	20	39	61
Evidence Screening & Processing	34	52	61
Explosives	32	47	114
Fingerprints	24	50	81
Fire analysis	24	48	143
Firearms and Ballistics	25	47	103
Forensic Pathology	31	36	39
Gun Shot Residue (GSR)	30	61	123
Marks and Impressions	40	57	122
Serology/Biology	26	48	77
Toxicology ante mortem (excluding BAC)	28	36	54
Toxicology post mortem (excluding BAC)	37	55	86
Trace Evidence	72	153	684

Backlog

Another area of concern involves the increased demand for laboratory services and the level of backlog. For data collection purposes, the definition of backlog has been defined as open cases at the end of the fiscal year that have been open for more than thirty days. As a relative comparative measure, the ratio of open cases to total cases for the year is presented in the following table.

Cases Open over 30 Days/Annual Caseload

Table 26: Backlog Cases as a Percent of Total Cases by Investigative Area

Area of Investigation	25th percentile	Median	75th percentile
Blood Alcohol	5%	8%	23%
Crime Scene Investigation	29%	74%	90%
Digital evidence - Audio & Video	70%	87%	95%
DNA Casework	36%	53%	69%
DNA Database	70%	72%	80%
Document Examination	62%	73%	84%
Drugs - Controlled Substances	25%	41%	61%
Evidence Screening & Processing	66%	81%	88%
Explosives	61%	80%	100%
Fingerprints	42%	54%	78%
Fire analysis	33%	55%	67%
Firearms and Ballistics	55%	78%	92%
Forensic Pathology	45%	68%	92%
Gun Shot Residue (GSR)	36%	47%	76%
Marks and Impressions	75%	87%	96%
Serology/Biology	38%	55%	69%
Toxicology ante mortem (excluding BAC)	24%	44%	52%
Toxicology post mortem (excluding BAC)	45%	52%	63%
Trace Evidence	67%	77%	90%

Efficiency and Cost Effectiveness of Forensic Science Services—FORESIGHT 2016-2017 Benchmark Data

The summary statistics offer a one-dimensional view of performance. In this section, that view is expanded through a consideration of cost effectiveness and efficiency. Economic theory indicates that any industry, including forensic science laboratories, will have average costs (Cost/Case) that decline as caseload is increased until reaching a point of perfect economies of scale. Thereafter, diseconomies of scale will be realized and average costs will rise as caseload increases. This behavior is exemplified via U-shaped average cost curves.

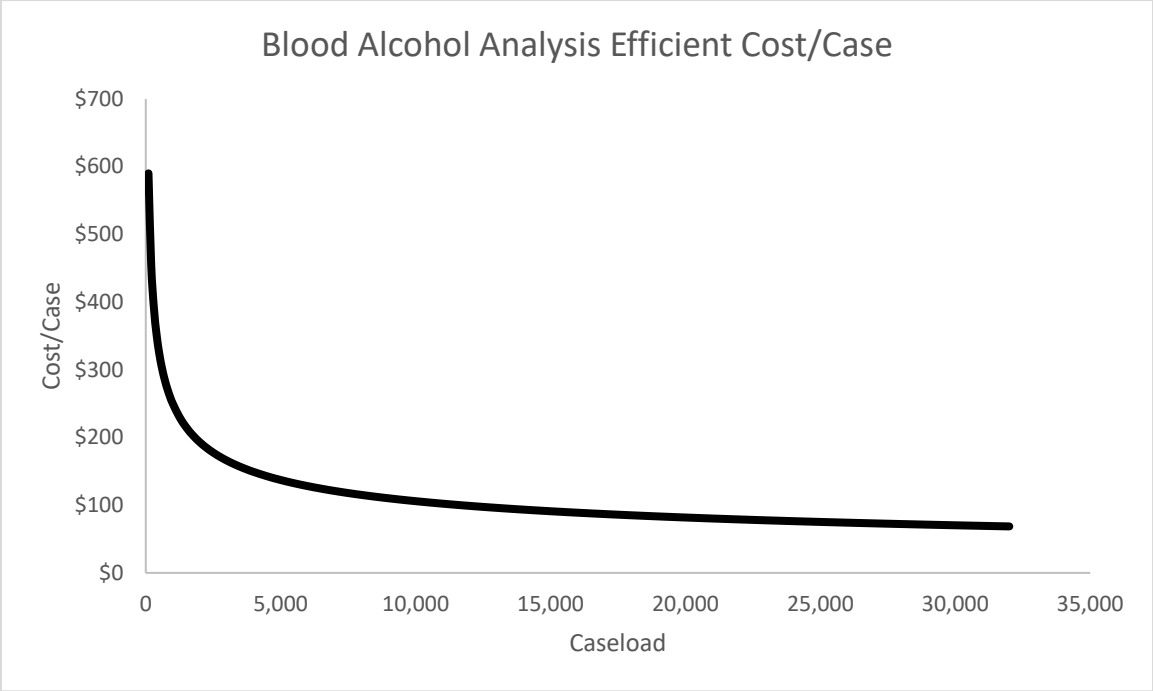
For each investigative area, the industry average total cost curve has been estimated by a series of non-linear regressions. When a laboratory performs on or near the curve, it is an indication of efficiency for the corresponding caseload. For an efficient performance that is near the bottom of the U-shaped curve, the laboratory exhibits cost effective performance as it approaches perfect economies of scale.

Each of the average cost curves is illustrated with a corresponding table of values for the cost/case for various caseloads. Also note that productivity in the form of Cases/FTE versus the corresponding caseload exhibits an inverted curve as compared to the average cost. Research to-date suggests that the level of productivity for any caseload is the most critical component in the DuPont breakdown to explain efficiency in the laboratory. That is, a laboratory which exemplifies high productivity for their caseload is likely to be operating near peak efficient average cost for that level of casework.

In addition to this cross–sectional comparison, it is recommended that participants track their average cost and productivity for all past FORESIGHT submissions in real terms. The term “real” indicates that costs have been adjusted for inflation and converted to the most recent year’s price index.

Blood Alcohol Analysis

Figure 1: Efficient Frontier for Blood Alcohol Analysis—Average Total Cost v. Caseload



Foresight Project 2016-2017, West Virginia University, Morgantown, WV, USA

Table 27: Efficient Frontier for Blood & Breath Alcohol Analysis—Efficient Cost/Case for Various Caseloads

Caseload	Blood Alcohol Analysis Efficient Cost/Case	Caseload	Blood Alcohol Analysis Efficient Cost/Case	Caseload	Blood Alcohol Analysis Efficient Cost/Case
100	$590	6,500	$124	19,500	$83
200	$456	7,000	$121	20,000	$82
300	$392	7,500	$118	20,500	$81
400	$352	8,000	$115	21,000	$80
500	$324	8,500	$113	21,500	$80
600	$303	9,000	$110	22,000	$79
700	$286	9,500	$108	22,500	$78
800	$272	10,000	$106	23,000	$78
900	$260	10,500	$104	23,500	$77
1,000	$250	11,000	$102	24,000	$76
1,250	$230	11,500	$101	24,500	$76
1,500	$215	12,000	$99	25,000	$75
1,750	$203	12,500	$97	25,500	$75
2,000	$193	13,000	$96	26,000	$74
2,250	$185	13,500	$95	26,500	$74
2,500	$178	14,000	$93	27,000	$73
2,750	$171	14,500	$92	27,500	$73
3,000	$166	15,000	$91	28,000	$72
3,250	$161	15,500	$90	28,500	$72
3,500	$157	16,000	$89	29,000	$71
3,750	$153	16,500	$88	29,500	$71
4,000	$149	17,000	$87	30,000	$70
4,500	$143	17,500	$86	30,500	$70
5,000	$137	18,000	$85	31,000	$69
5,500	$132	18,500	$84	31,500	$69
6,000	$128	19,000	$83	32,000	$69

Crime Scene Investigation

Figure 2: Efficient Frontier for Crime Scene Investigation--Average Total Cost v. Caseload

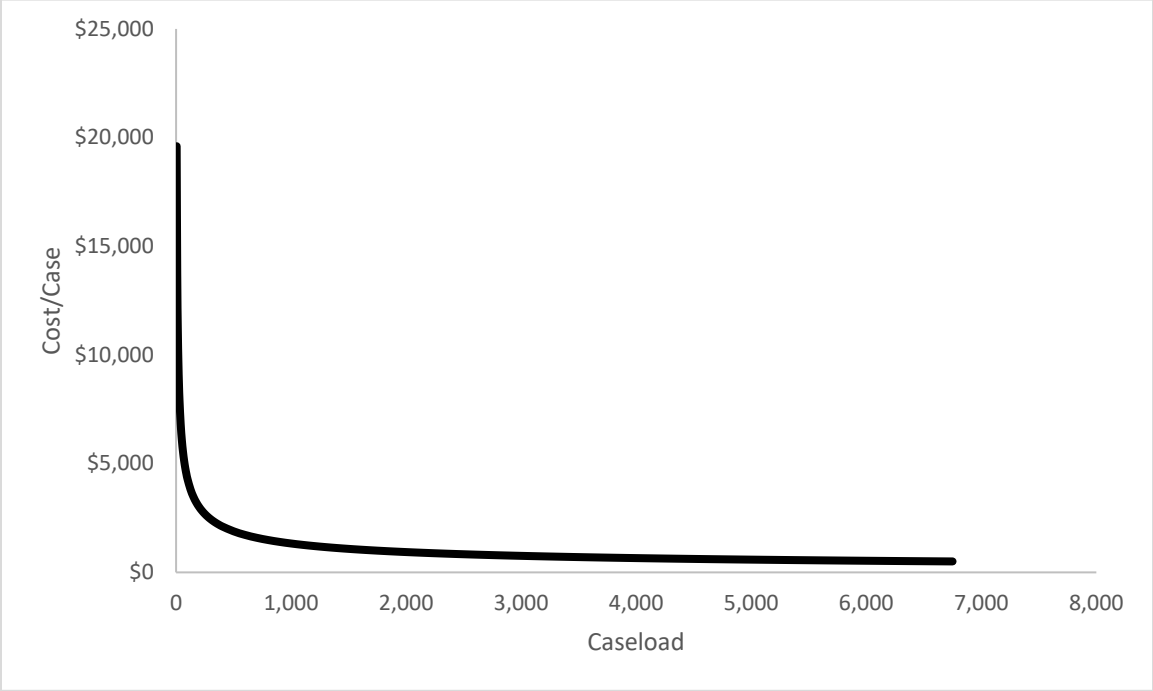


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Table 28: Efficient Frontier for Crime Scene Investigation—Efficient Cost/Case for Various Caseloads

Caseload	CSI Efficient Cost/Case	Caseload	CSI Efficient Cost/Case	Caseload	CSI Efficient Cost/Case
5	$19,605	600	$1,723	3,200	$736
10	$13,786	700	$1,593	3,300	$725
15	$11,220	800	$1,488	3,400	$714
20	$9,695	900	$1,402	3,500	$703
25	$8,656	1,000	$1,329	3,600	$693
30	$7,890	1,100	$1,266	3,700	$684
40	$6,817	1,200	$1,211	3,800	$675
50	$6,087	1,300	$1,163	3,900	$666
60	$5,548	1,400	$1,120	4,000	$657
70	$5,131	1,500	$1,082	4,100	$649
80	$4,794	1,600	$1,047	4,200	$641
90	$4,516	1,700	$1,015	4,300	$633
100	$4,280	1,800	$986	4,400	$626
125	$3,822	1,900	$959	4,500	$619
150	$3,484	2,000	$935	4,600	$612
175	$3,221	2,100	$912	4,700	$605
200	$3,010	2,200	$890	4,800	$599
225	$2,835	2,300	$870	4,900	$593
250	$2,687	2,400	$852	5,000	$587
275	$2,560	2,500	$834	5,250	$572
300	$2,450	2,600	$818	5,500	$559
325	$2,352	2,700	$802	5,750	$547
350	$2,265	2,800	$788	6,000	$535
375	$2,187	2,900	$774	6,250	$524
400	$2,117	3,000	$761	6,500	$514
500	$1,890	3,100	$748	6,750	$504

Digital Evidence

There was insufficient information to estimate the efficient frontier for digital evidence.

DNA Casework Analysis

Figure 3: Efficient Frontier for DNA Casework Analysis--Average Total Cost v. Caseload

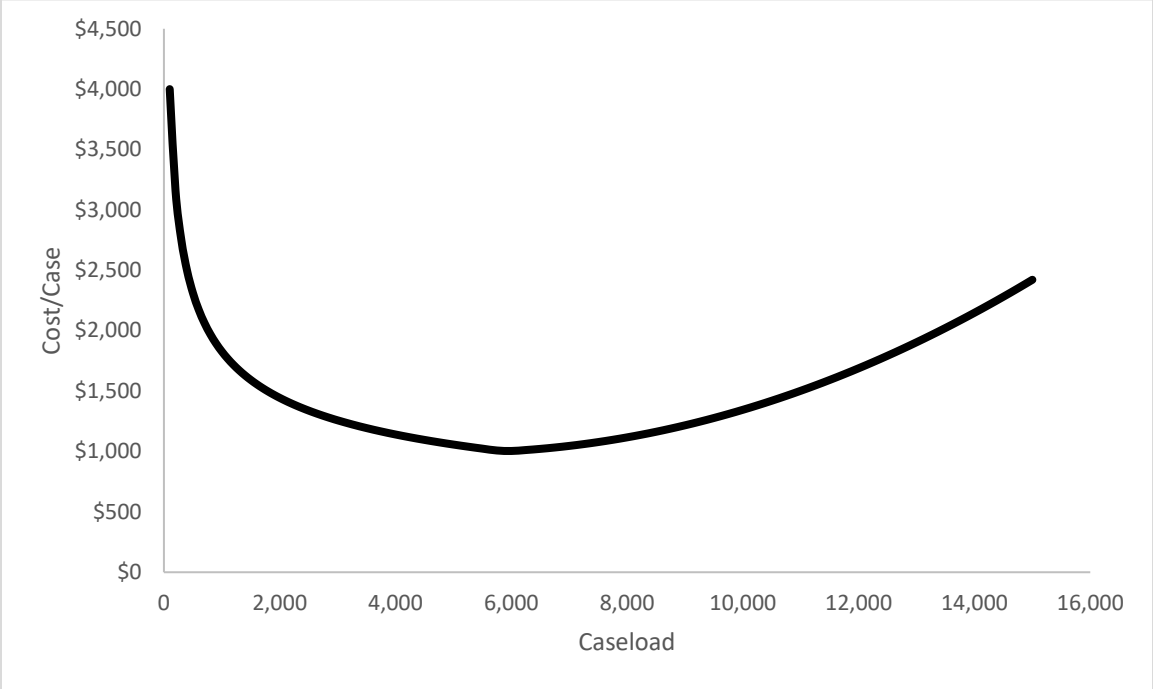

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Table 29: Efficient Frontier for DNA Casework—Efficient Cost/Case for Various Caseloads

Caseload	DNA Casework Efficient Cost/Case	Caseload	DNA Casework Efficient Cost/Case	Caseload	DNA Casework Efficient Cost/Case
100	$4,000	2,700	$1,304	8,750	$1,189
200	$3,160	2,800	$1,288	9,000	$1,217
300	$2,753	2,900	$1,272	9,250	$1,246
400	$2,496	3,000	$1,258	9,500	$1,277
500	$2,314	3,250	$1,224	9,750	$1,310
600	$2,175	3,500	$1,194	10,000	$1,345
700	$2,064	3,750	$1,166	10,250	$1,382
800	$1,972	4,000	$1,141	10,500	$1,420
900	$1,895	4,250	$1,117	10,750	$1,461
1,000	$1,828	4,500	$1,096	11,000	$1,503
1,100	$1,770	4,750	$1,076	11,250	$1,547
1,200	$1,718	5,000	$1,057	11,500	$1,592
1,300	$1,672	5,250	$1,040	11,750	$1,640
1,400	$1,630	5,500	$1,024	12,000	$1,689
1,500	$1,592	5,750	$1,008	12,250	$1,740
1,600	$1,558	6,000	$1,004	12,500	$1,793
1,700	$1,526	6,250	$1,012	12,750	$1,848
1,800	$1,497	6,500	$1,021	13,000	$1,904
1,900	$1,469	6,750	$1,033	13,250	$1,963
2,000	$1,444	7,000	$1,046	13,500	$2,023
2,100	$1,420	7,250	$1,061	13,750	$2,085
2,200	$1,398	7,500	$1,078	14,000	$2,149
2,300	$1,377	7,750	$1,096	14,250	$2,214
2,400	$1,357	8,000	$1,117	14,500	$2,281
2,500	$1,338	8,250	$1,139	14,750	$2,351
2,600	$1,321	8,500	$1,163	15,000	$2,422

DNA Database

Figure 4: Efficient Frontier for DNA Database--Average Total Cost v. Caseload

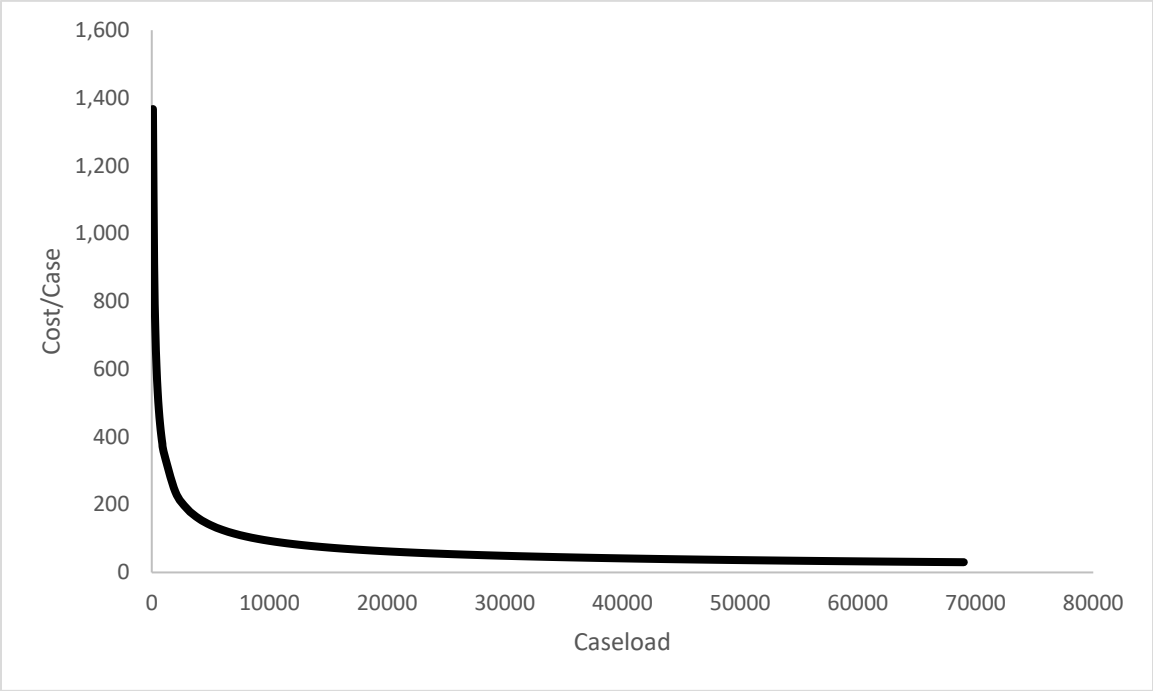

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Table 30: Efficient Frontier for DNA Database—Efficient Cost/Case for Various Caseloads

Caseload	DNA Database Efficient Cost/Case	Caseload	DNA Database Efficient Cost/Case	Caseload	DNA Database Efficient Cost/Case
100	$1,367	18,000	$66	44,000	$39
200	$913	19,000	$64	45,000	$39
300	$720	20,000	$62	46,000	$38
400	$609	21,000	$60	47,000	$38
500	$535	22,000	$59	48,000	$37
600	$481	23,000	$57	49,000	$37
700	$439	24,000	$56	50,000	$36
800	$407	25,000	$55	51,000	$36
900	$380	26,000	$53	52,000	$36
1,000	$357	27,000	$52	53,000	$35
2,000	$238	28,000	$51	54,000	$35
3,000	$188	29,000	$50	55,000	$34
4,000	$159	30,000	$49	56,000	$34
5,000	$140	31,000	$48	57,000	$34
6,000	$126	32,000	$47	58,000	$33
7,000	$115	33,000	$46	59,000	$33
8,000	$106	34,000	$46	60,000	$33
9,000	$99	35,000	$45	61,000	$32
10,000	$93	36,000	$44	62,000	$32
11,000	$88	37,000	$43	63,000	$32
12,000	$84	38,000	$43	64,000	$32
13,000	$80	39,000	$42	65,000	$31
14,000	$77	40,000	$42	66,000	$31
15,000	$74	41,000	$41	67,000	$31
16,000	$71	42,000	$40	68,000	$30
17,000	$68	43,000	$40	69,000	$30

Document Examination

Figure 5: Efficient Frontier for Document Examination--Average Total Cost v. Caseload

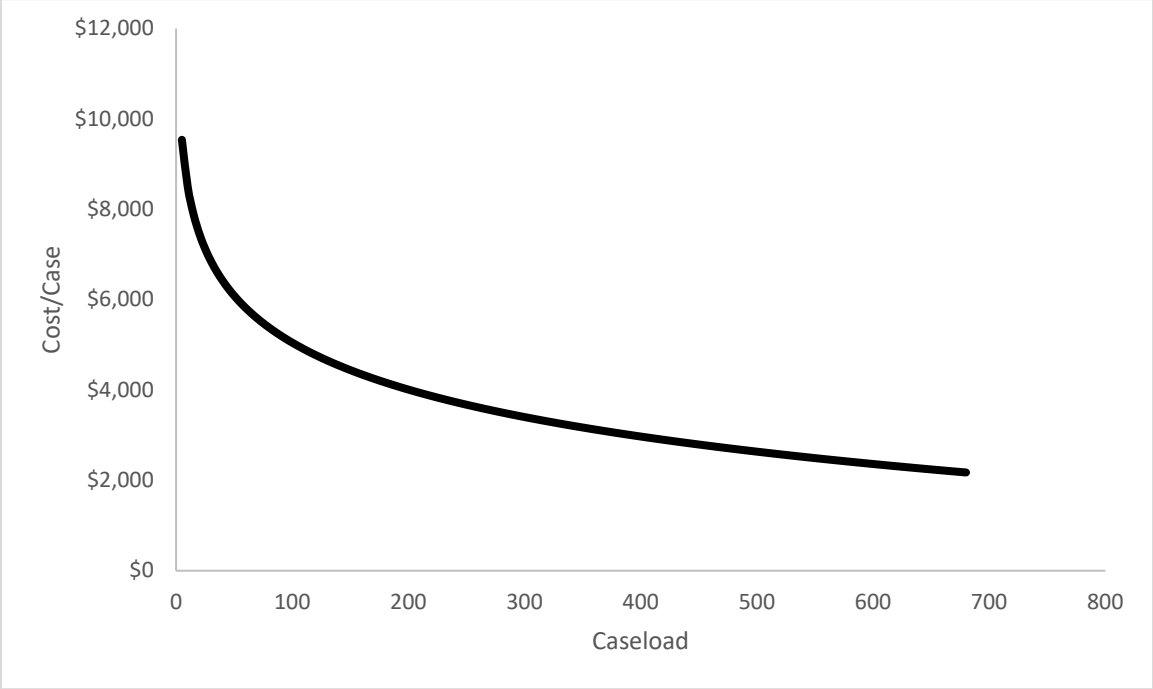

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Table 31: Efficient Frontier for Document Examination—Efficient Cost/Case for Various Caseloads

Caseload	Document Examination Efficient Cost/Case	Caseload	Document Examination Efficient Cost/Case	Caseload	Document Examination Efficient Cost/Case
5	$9,537	170	$4,252	430	$2,861
10	$8,498	180	$4,166	440	$2,827
15	$7,891	190	$4,085	450	$2,793
20	$7,459	200	$4,008	460	$2,760
25	$7,125	210	$3,935	470	$2,728
30	$6,852	220	$3,866	480	$2,696
35	$6,621	230	$3,799	490	$2,666
40	$6,421	240	$3,735	500	$2,635
45	$6,244	250	$3,674	510	$2,606
50	$6,086	260	$3,615	520	$2,576
55	$5,943	270	$3,559	530	$2,548
60	$5,813	280	$3,504	540	$2,520
65	$5,693	290	$3,452	550	$2,492
70	$5,582	300	$3,401	560	$2,465
75	$5,478	310	$3,352	570	$2,439
80	$5,382	320	$3,304	580	$2,413
85	$5,291	330	$3,258	590	$2,387
90	$5,205	340	$3,213	600	$2,362
95	$5,124	350	$3,170	610	$2,337
100	$5,047	360	$3,128	620	$2,313
110	$4,904	370	$3,087	630	$2,289
120	$4,774	380	$3,047	640	$2,265
130	$4,654	390	$3,008	650	$2,242
140	$4,543	400	$2,970	660	$2,219
150	$4,440	410	$2,933	670	$2,197
160	$4,343	420	$2,897	680	$2,174

Drugs—Controlled Substances

Figure 6: Efficient Frontier for Drugs-Controlled Substances Analysis-- Average Total Cost v. Caseload

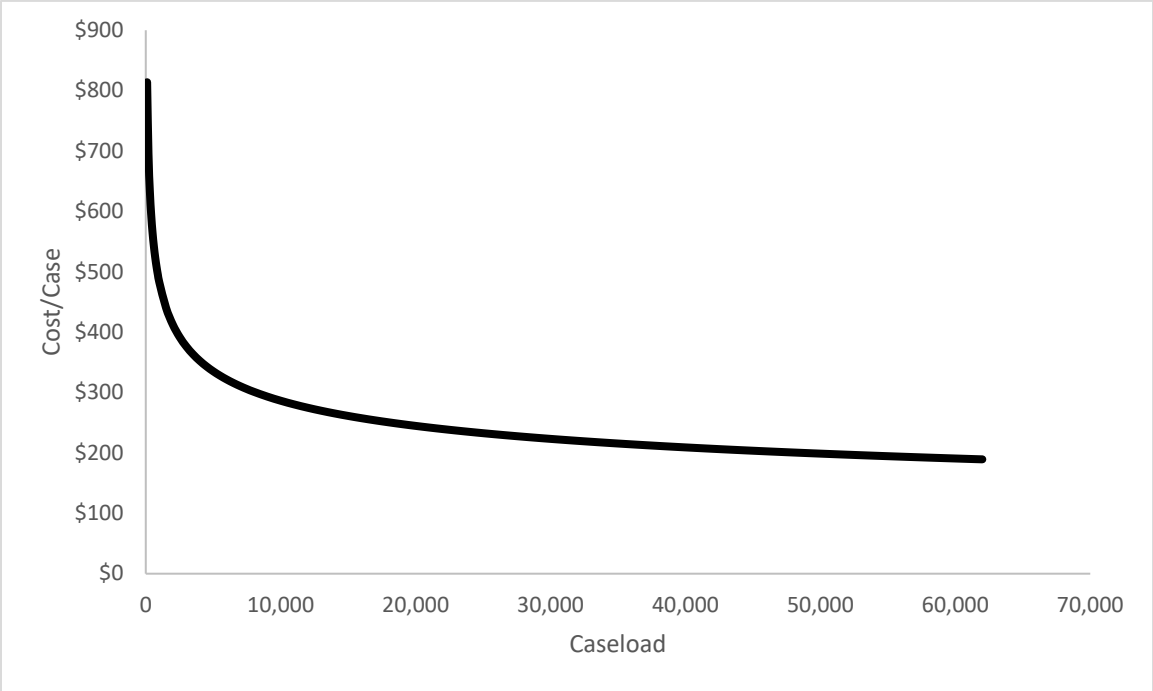

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Table 32: Efficient Frontier for Drugs-Controlled Substances Analysis—Efficient Cost/Case for Various Caseloads

Caseload	Drugs-Controlled Substances Analysis Efficient Cost/Case	Caseload	Drugs-Controlled Substances Analysis Efficient Cost/Case	Caseload	Drugs-Controlled Substances Analysis Efficient Cost/Case
100	$814	11,000	$280	37,000	$213
200	$695	12,000	$275	38,000	$212
300	$634	13,000	$270	39,000	$210
400	$594	14,000	$265	40,000	$209
500	$565	15,000	$261	41,000	$208
600	$542	16,000	$257	42,000	$207
700	$523	17,000	$254	43,000	$206
800	$508	18,000	$251	44,000	$205
900	$494	19,000	$248	45,000	$204
1,000	$483	20,000	$245	46,000	$203
1,500	$440	21,000	$242	47,000	$202
2,000	$413	22,000	$240	48,000	$201
2,500	$392	23,000	$237	49,000	$200
3,000	$376	24,000	$235	50,000	$199
3,500	$363	25,000	$233	51,000	$198
4,000	$353	26,000	$231	52,000	$197
4,500	$343	27,000	$229	53,000	$196
5,000	$335	28,000	$227	54,000	$195
5,500	$328	29,000	$225	55,000	$195
6,000	$322	30,000	$223	56,000	$194
6,500	$316	31,000	$222	57,000	$193
7,000	$311	32,000	$220	58,000	$192
7,500	$306	33,000	$218	59,000	$192
8,000	$301	34,000	$217	60,000	$191
9,000	$293	35,000	$216	61,000	$190
10,000	$286	36,000	$214	62,000	$189

Evidence Screening & Processing

There was insufficient data to model this area of investigation.

Explosives Analysis

Figure 7: Efficient Frontier for Explosives Analysis--Average Total Cost v. Caseload

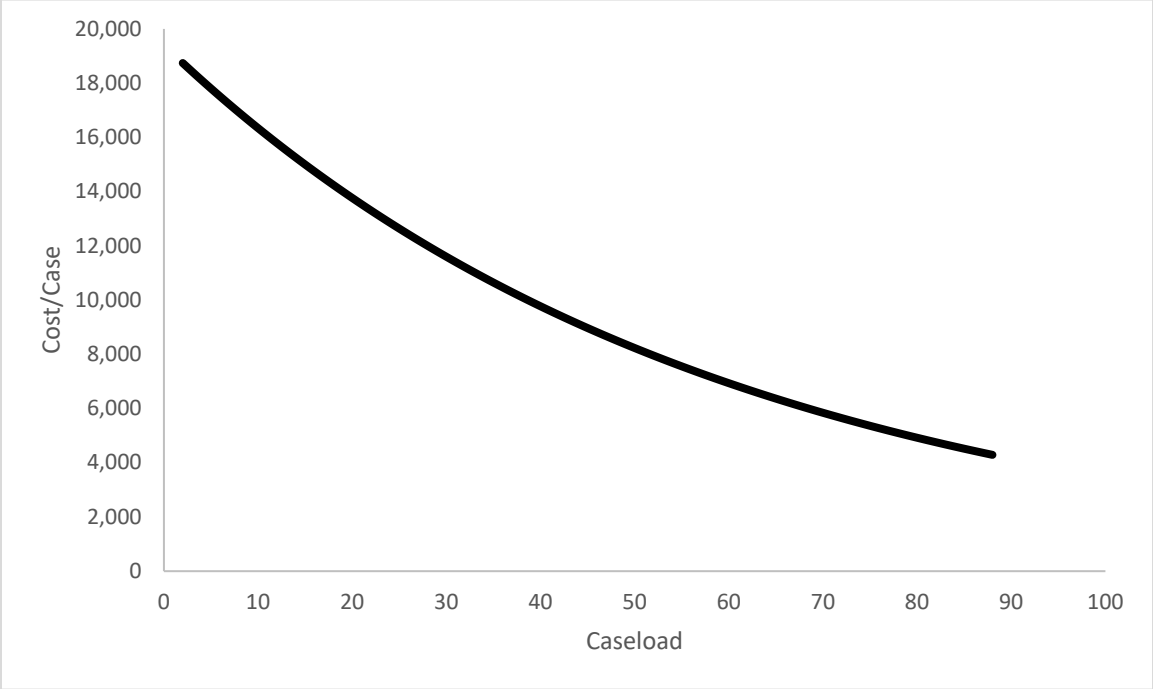

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Table 33: Efficient Frontier for Explosives Analysis—Efficient Cost/Case for Various Caseloads

Caseload	Explosives Analysis Efficient Cost/Case	Caseload	Explosives Analysis Efficient Cost/Case	Caseload	Explosives Analysis Efficient Cost/Case
2	$18,742	28	$12,001	54	$7,685
3	$18,423	29	$11,797	55	$7,554
4	$18,110	30	$11,597	56	$7,426
5	$17,802	31	$11,400	57	$7,300
6	$17,500	32	$11,206	58	$7,176
7	$17,202	33	$11,015	59	$7,054
8	$16,910	34	$10,828	60	$6,934
9	$16,622	35	$10,644	61	$6,816
10	$16,340	36	$10,463	62	$6,700
11	$16,062	37	$10,285	63	$6,586
12	$15,789	38	$10,110	64	$6,474
13	$15,521	39	$9,939	65	$6,364
14	$15,257	40	$9,770	66	$6,256
15	$14,998	41	$9,604	67	$6,150
16	$14,743	42	$9,440	68	$6,045
17	$14,492	43	$9,280	69	$5,942
18	$14,246	44	$9,122	70	$5,841
19	$14,004	45	$8,967	72	$5,644
20	$13,765	46	$8,815	74	$5,454
21	$13,532	47	$8,665	76	$5,270
22	$13,301	48	$8,518	78	$5,093
23	$13,075	49	$8,373	80	$4,921
24	$12,853	50	$8,230	82	$4,755
25	$12,635	51	$8,091	84	$4,595
26	$12,420	52	$7,953	86	$4,440
27	$12,209	53	$7,818	88	$4,290

Fingerprint ID

Figure 8: Efficient Frontier for Fingerprint Identification--Average Total Cost v. Caseload

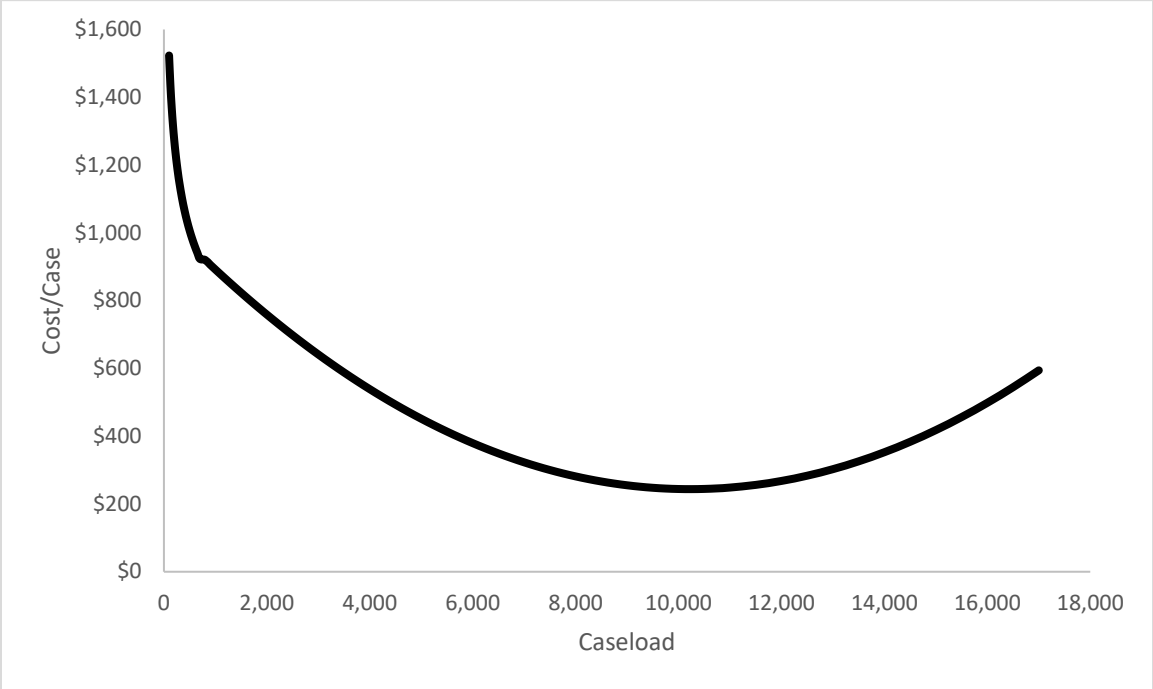

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Table 34: Efficient Frontier for Fingerprint Identification Analysis—Efficient Cost/Case for Various Caseloads

Caseload	Fingerprint Identification Efficient Cost/Case	Caseload	Fingerprint Identification Efficient Cost/Case	Caseload	Fingerprint Identification Efficient Cost/Case
100	$1,523	1,700	$797	7,750	$290
125	$1,438	1,800	$784	8,000	$281
150	$1,372	1,900	$771	8,250	$273
175	$1,319	2,000	$759	8,500	$266
200	$1,274	2,250	$728	8,750	$260
225	$1,236	2,500	$698	9,000	$255
250	$1,203	2,750	$669	9,250	$251
275	$1,174	3,000	$641	9,500	$248
300	$1,148	3,250	$614	9,750	$245
350	$1,103	3,500	$588	10,000	$244
400	$1,066	3,750	$563	10,250	$244
450	$1,034	4,000	$539	10,500	$244
500	$1,006	4,250	$515	10,750	$246
550	$982	4,500	$493	11,000	$248
600	$960	4,750	$472	11,500	$256
650	$941	5,000	$451	12,000	$268
700	$923	5,250	$432	12,500	$283
800	$920	5,500	$414	13,000	$303
900	$906	5,750	$396	13,500	$326
1,000	$892	6,000	$379	14,000	$353
1,100	$878	6,250	$364	14,500	$383
1,200	$864	6,500	$349	15,000	$418
1,300	$850	6,750	$336	15,500	$456
1,400	$837	7,000	$323	16,000	$498
1,500	$823	7,250	$311	16,500	$544
1,600	$810	7,500	$300	17,000	$594

Fire Analysis

Figure 9: Efficient Frontier for Fire Analysis--Average Total Cost v. Caseload

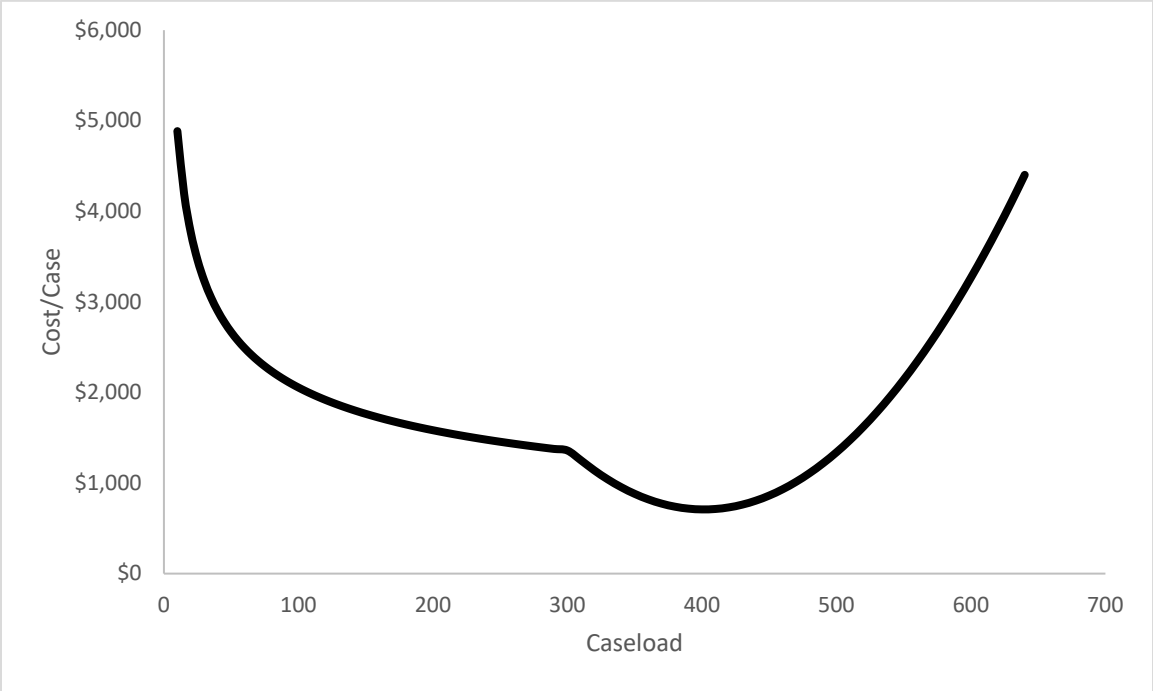

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Table 35: Efficient Frontier for Fire Analysis—Efficient Cost/Case for Various Caseloads

Caseload	Fire Analysis Efficient Cost/Case	Caseload	Fire Analysis Efficient Cost/Case	Caseload	Fire Analysis Efficient Cost/Case
10	$4,885	140	$1,810	390	$717
15	$4,194	145	$1,787	400	$709
20	$3,764	150	$1,764	410	$714
25	$3,461	160	$1,722	420	$731
30	$3,231	170	$1,683	430	$762
35	$3,049	180	$1,647	440	$805
40	$2,900	190	$1,614	450	$862
45	$2,774	200	$1,583	460	$931
50	$2,667	210	$1,554	470	$1,014
55	$2,573	220	$1,527	480	$1,109
60	$2,490	230	$1,502	490	$1,218
65	$2,416	240	$1,478	500	$1,339
70	$2,350	250	$1,456	510	$1,473
75	$2,289	260	$1,434	520	$1,621
80	$2,234	270	$1,414	530	$1,781
85	$2,184	280	$1,395	540	$1,955
90	$2,138	290	$1,376	550	$2,141
95	$2,095	300	$1,359	560	$2,340
100	$2,055	310	$1,252	570	$2,553
105	$2,017	320	$1,140	580	$2,778
110	$1,982	330	$1,040	590	$3,016
115	$1,949	340	$954	600	$3,267
120	$1,918	350	$881	610	$3,532
125	$1,889	360	$820	620	$3,809
130	$1,861	370	$773	630	$4,099
135	$1,835	380	$739	640	$4,402

Firearms & Ballistics Analysis

Figure 10: Efficient Frontier for Firearms & Ballistics Analysis--Average Total Cost v. Caseload

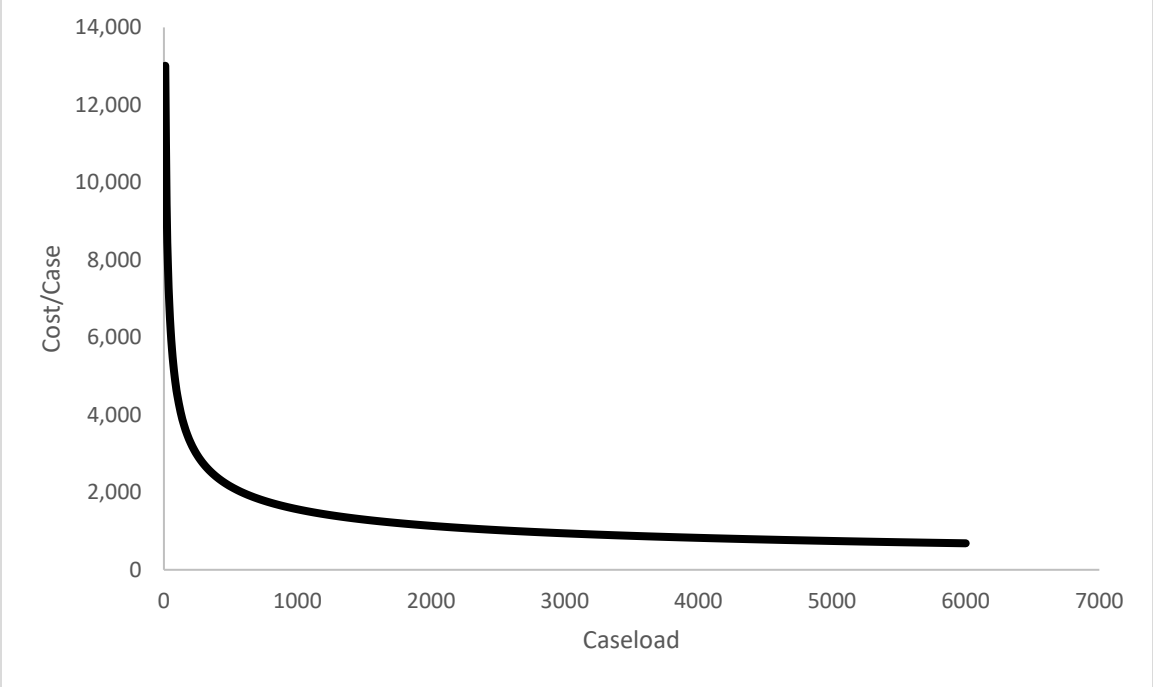

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Table 36: Efficient Frontier for Firearms & Ballistics Analysis—Efficient Cost/Case for Various Caseloads

Caseload	Firearms & Ballistics Analysis Efficient Cost/Case	Caseload	Firearms & Ballistics Analysis Efficient Cost/Case	Caseload	Firearms & Ballistics Analysis Efficient Cost/Case
10	$13,010	550	$2,056	1,850	$1,176
20	$9,456	600	$1,975	1,900	$1,162
30	$7,845	650	$1,904	1,950	$1,148
40	$6,872	700	$1,840	2,000	$1,135
50	$6,201	750	$1,782	2,100	$1,110
60	$5,702	800	$1,730	2,200	$1,086
70	$5,311	850	$1,683	2,300	$1,064
80	$4,995	900	$1,639	2,400	$1,043
90	$4,731	950	$1,599	2,500	$1,024
100	$4,507	1,000	$1,561	2,600	$1,006
125	$4,067	1,050	$1,527	2,700	$988
150	$3,739	1,100	$1,494	2,800	$972
175	$3,483	1,150	$1,464	2,900	$956
200	$3,276	1,200	$1,436	3,000	$941
225	$3,103	1,250	$1,409	3,250	$907
250	$2,956	1,300	$1,384	3,500	$877
275	$2,829	1,350	$1,360	3,750	$850
300	$2,718	1,400	$1,337	4,000	$825
325	$2,619	1,450	$1,316	4,250	$802
350	$2,532	1,500	$1,295	4,500	$781
375	$2,452	1,550	$1,276	4,750	$762
400	$2,381	1,600	$1,258	5,000	$744
425	$2,315	1,650	$1,240	5,250	$728
450	$2,255	1,700	$1,223	5,500	$712
475	$2,200	1,750	$1,207	5,750	$698
500	$2,148	1,800	$1,191	6,000	$684

Forensic Pathology

There is insufficient data to estimate the average total cost curve for this area of investigation.

Gunshot Residue

Figure 11: Efficient Frontier for Gunshot Residue Analysis--Average Total Cost v. Caseload

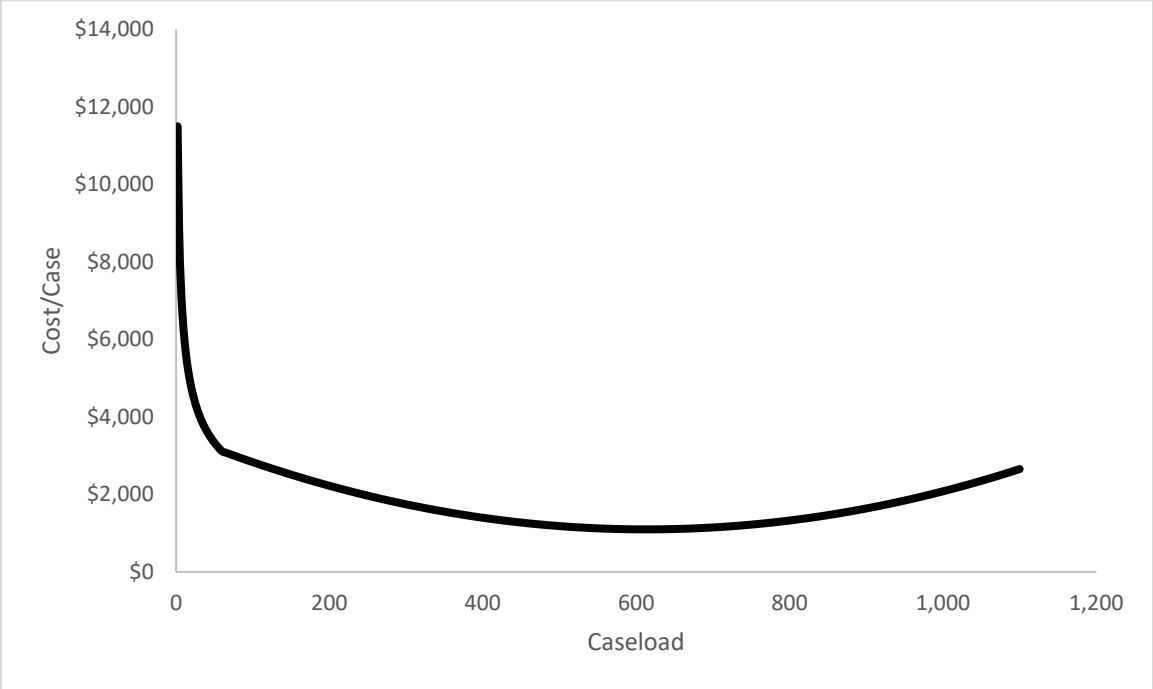

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Table 37: Efficient Frontier for Gunshot Residue Analysis—Efficient Cost/Case for Various Caseloads

Caseload	Gunshot Residue Efficient Cost/Case	Caseload	Gunshot Residue Efficient Cost/Case	Caseload	Gunshot Residue Efficient Cost/Case
2	$11,504	110	$2,765	475	$1,223
4	$8,811	120	$2,699	500	$1,182
6	$7,539	130	$2,635	525	$1,149
8	$6,749	140	$2,572	550	$1,124
10	$6,194	150	$2,511	575	$1,107
12	$5,774	160	$2,450	600	$1,098
14	$5,442	170	$2,391	625	$1,098
16	$5,170	180	$2,333	650	$1,106
18	$4,941	190	$2,277	675	$1,122
20	$4,744	200	$2,222	700	$1,146
25	$4,354	210	$2,168	725	$1,179
30	$4,059	220	$2,116	750	$1,220
35	$3,826	230	$2,065	775	$1,269
40	$3,634	240	$2,015	800	$1,326
45	$3,473	250	$1,966	825	$1,391
50	$3,335	260	$1,919	850	$1,465
55	$3,215	270	$1,873	875	$1,547
60	$3,113	280	$1,829	900	$1,637
65	$3,076	290	$1,786	925	$1,735
70	$3,041	300	$1,744	950	$1,842
75	$3,005	325	$1,645	975	$1,957
80	$2,970	350	$1,554	1,000	$2,080
85	$2,935	375	$1,471	1,025	$2,211
90	$2,900	400	$1,397	1,050	$2,350
95	$2,866	425	$1,331	1,075	$2,498
100	$2,832	450	$1,273	1,100	$2,654

Marks & Impressions Analysis

Figure 12: Efficient Frontier for Marks & Impressions Analysis--Average Total Cost v. Caseload

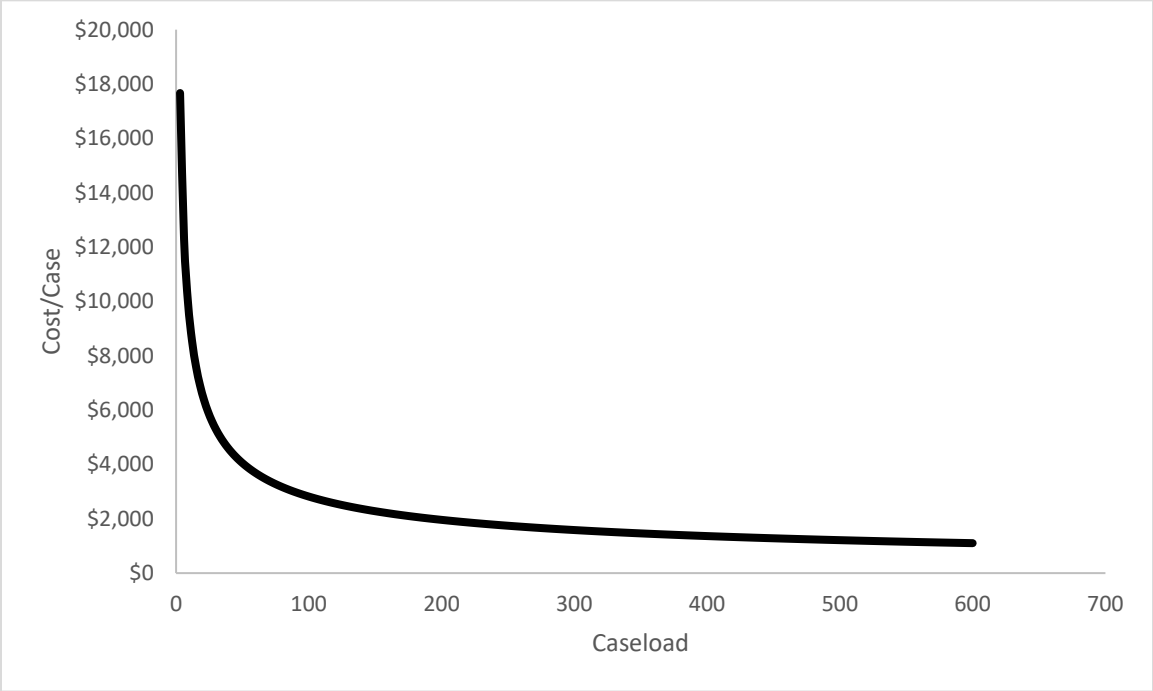

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Table 38: Efficient Frontier for Marks & Impressions Analysis—Efficient Cost/Case for Various Caseloads

Caseload	Marks & Impressions Efficient Cost/Case	Caseload	Marks & Impressions Efficient Cost/Case	Caseload	Marks & Impressions Efficient Cost/Case
3	$17,668	81	$3,146	260	$1,708
6	$12,290	84	$3,086	270	$1,675
9	$9,939	87	$3,030	280	$1,643
12	$8,549	90	$2,977	290	$1,613
15	$7,607	95	$2,894	300	$1,585
18	$6,914	100	$2,817	310	$1,558
21	$6,378	105	$2,746	320	$1,532
24	$5,947	110	$2,680	330	$1,508
27	$5,592	115	$2,618	340	$1,484
30	$5,291	120	$2,560	350	$1,462
33	$5,034	125	$2,506	360	$1,440
36	$4,810	130	$2,455	370	$1,420
39	$4,612	135	$2,407	380	$1,400
42	$4,437	140	$2,362	390	$1,381
45	$4,279	145	$2,319	400	$1,363
48	$4,137	150	$2,278	410	$1,346
51	$4,008	160	$2,202	420	$1,329
54	$3,890	170	$2,134	430	$1,312
57	$3,781	180	$2,071	440	$1,297
60	$3,681	190	$2,013	450	$1,282
63	$3,588	200	$1,960	475	$1,246
66	$3,502	210	$1,910	500	$1,213
69	$3,421	220	$1,864	525	$1,182
72	$3,346	230	$1,821	550	$1,154
75	$3,275	240	$1,781	575	$1,127
78	$3,208	250	$1,743	600	$1,102

Serology/Biology

Figure 13: Efficient Frontier for Serology/Biology Analysis--Average Total Cost v. Caseload

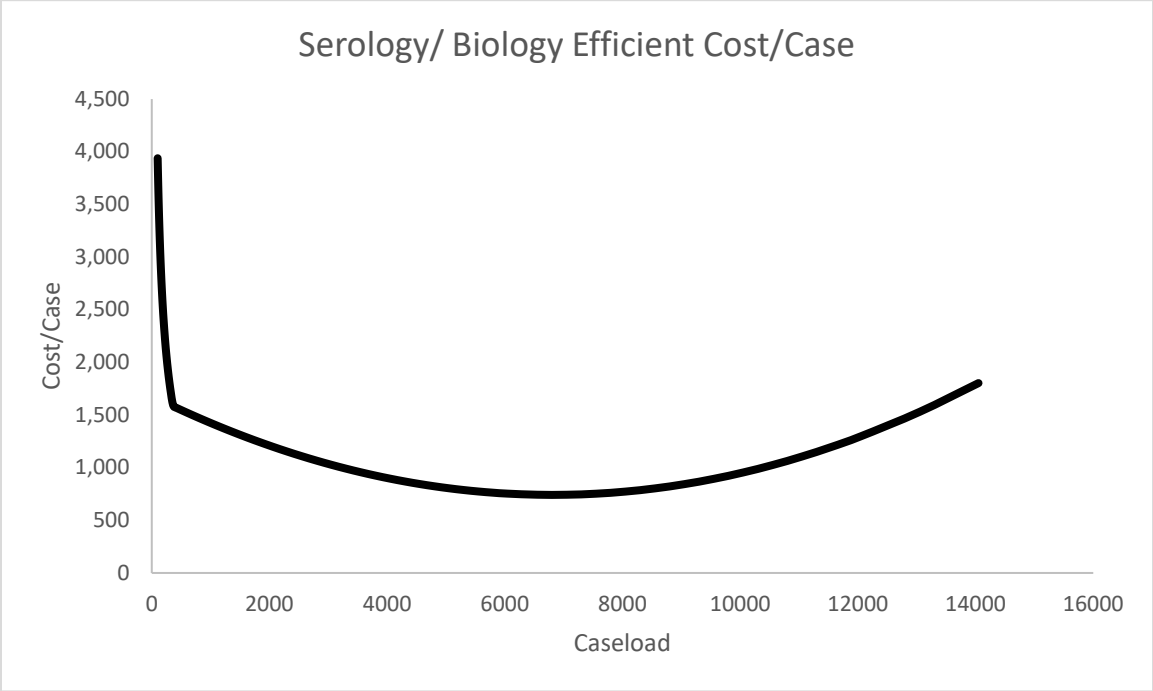

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Table 39: Efficient Frontier for Serology/Biology Analysis—Efficient Cost/Case for Various Caseloads

Caseload	Serology/ Biology Efficient Cost/Case	Caseload	Serology/ Biology Efficient Cost/Case	Caseload	Serology/ Biology Efficient Cost/Case
10	$20,101	375	$1,579	3,300	$991
20	$12,306	400	$1,573	3,550	$956
30	$9,235	425	$1,566	3,800	$925
40	$7,534	450	$1,560	4,050	$896
50	$6,433	475	$1,553	4,300	$869
60	$5,654	500	$1,547	4,550	$845
70	$5,069	550	$1,534	4,800	$823
80	$4,612	600	$1,522	5,050	$804
90	$4,243	650	$1,509	5,300	$788
100	$3,938	700	$1,497	5,550	$774
110	$3,681	800	$1,472	5,800	$762
120	$3,461	900	$1,448	6,050	$753
130	$3,271	1,000	$1,424	6,550	$743
140	$3,103	1,100	$1,401	7,050	$743
150	$2,956	1,200	$1,378	7,550	$753
160	$2,824	1,300	$1,356	8,050	$773
170	$2,705	1,400	$1,334	8,550	$803
180	$2,598	1,500	$1,312	9,050	$843
190	$2,500	1,600	$1,291	9,550	$894
200	$2,411	1,700	$1,270	10,050	$954
225	$2,218	1,800	$1,249	10,550	$1,025
250	$2,059	2,050	$1,200	11,050	$1,106
275	$1,924	2,300	$1,153	11,550	$1,197
300	$1,809	2,550	$1,109	12,050	$1,298
325	$1,710	2,800	$1,067	13,050	$1,530
350	$1,622	3,050	$1,027	14,050	$1,803

Toxicology Analysis ante mortem

Figure 14: Efficient Frontier for Toxicology Analysis ante mortem—Average Total Cost v. Caseload

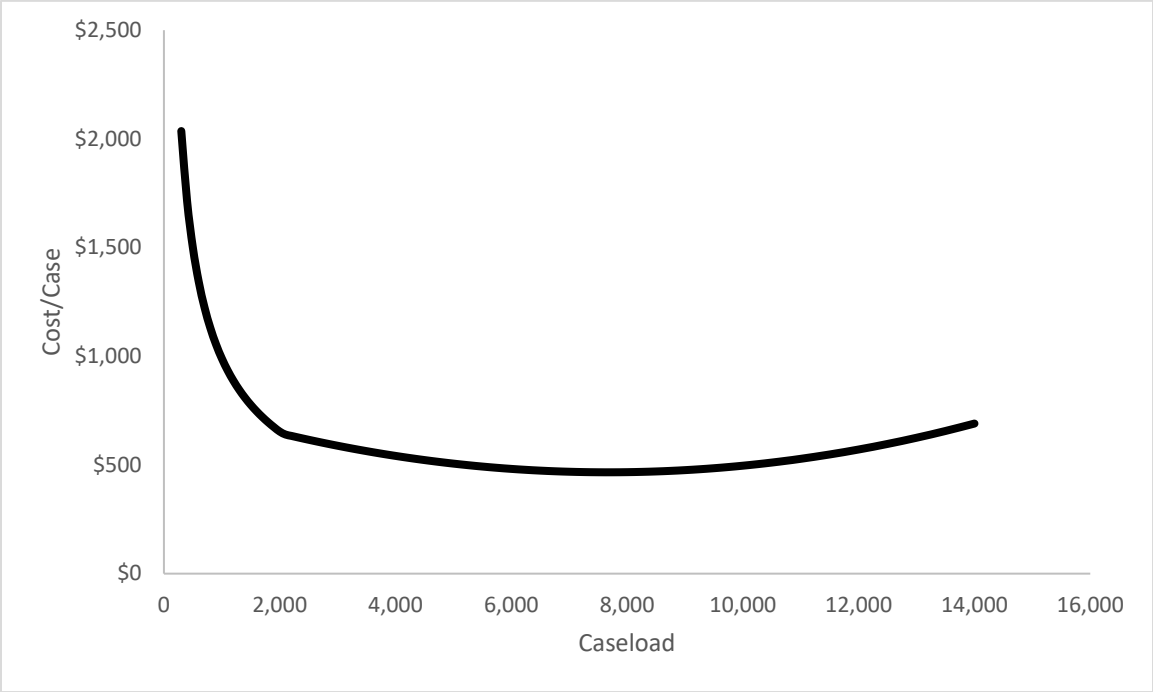

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Table 40: Efficient Frontier for Toxicology ante mortem—Efficient Cost/Case for Various Caseloads

Caseload	Toxicology ante mortem Efficient Cost/Case	Caseload	Toxicology ante mortem Efficient Cost/Case	Caseload	Toxicology ante mortem Efficient Cost/Case
300	$2,036	2,900	$594	6,250	$478
400	$1,714	3,000	$588	6,500	$474
500	$1,499	3,100	$583	6,750	$471
600	$1,344	3,200	$578	7,000	$469
700	$1,226	3,300	$573	7,250	$467
800	$1,131	3,400	$568	7,500	$466
900	$1,054	3,500	$564	7,750	$466
1,000	$990	3,600	$559	8,000	$467
1,100	$935	3,700	$554	8,250	$468
1,200	$888	3,800	$550	8,500	$470
1,300	$846	3,900	$546	8,750	$473
1,400	$809	4,000	$542	9,000	$476
1,500	$777	4,100	$538	9,250	$480
1,600	$747	4,200	$534	9,500	$485
1,700	$720	4,300	$530	9,750	$490
1,800	$696	4,400	$526	10,000	$497
1,900	$674	4,500	$523	10,250	$503
2,000	$654	4,600	$519	10,500	$511
2,100	$640	4,700	$516	10,750	$519
2,200	$634	4,800	$512	11,000	$528
2,300	$628	4,900	$509	11,500	$548
2,400	$622	5,000	$506	12,000	$571
2,500	$616	5,250	$499	12,500	$597
2,600	$610	5,500	$493	13,000	$625
2,700	$605	5,750	$487	13,500	$656
2,800	$599	6,000	$482	14,000	$690

Toxicology Analysis post mortem

Figure 15: Efficient Frontier for Toxicology Analysis post mortem—Average Total Cost v. Caseload

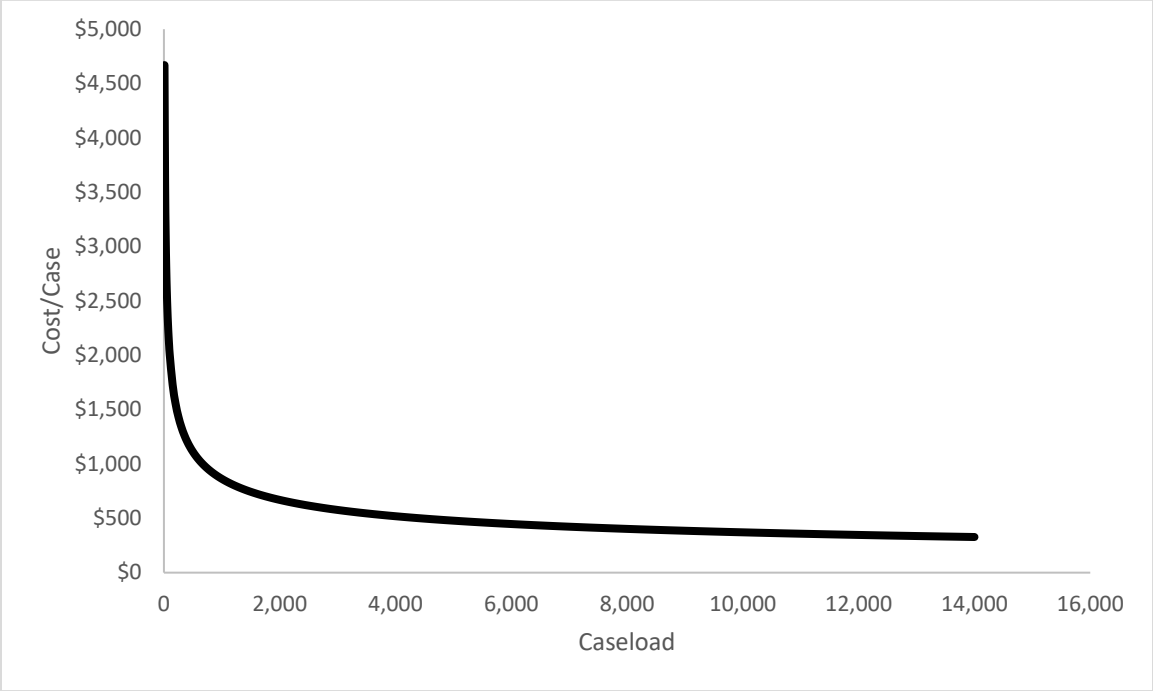

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Table 41: Efficient Frontier for Toxicology post mortem—Efficient Cost/Case for Various Caseloads

Caseload	Toxicology post mortem Efficient Cost/Case	Caseload	Toxicology post mortem Efficient Cost/Case	Caseload	Toxicology post mortem Efficient Cost/Case
10	$4,670	950	$879	3,750	$532
20	$3,622	1,000	$863	4,000	$519
30	$3,121	1,050	$848	4,250	$508
40	$2,809	1,100	$833	4,500	$497
50	$2,588	1,150	$820	4,750	$487
60	$2,421	1,200	$807	5,000	$478
70	$2,288	1,250	$795	5,250	$470
80	$2,179	1,300	$784	5,500	$462
90	$2,087	1,350	$773	5,750	$454
100	$2,007	1,400	$763	6,000	$447
150	$1,730	1,450	$753	6,250	$441
200	$1,557	1,500	$744	6,500	$434
250	$1,435	1,600	$726	6,750	$428
300	$1,342	1,700	$710	7,000	$423
350	$1,268	1,800	$696	7,250	$417
400	$1,208	1,900	$682	7,500	$412
450	$1,156	2,000	$669	8,000	$403
500	$1,113	2,100	$657	8,500	$394
550	$1,074	2,200	$646	9,000	$386
600	$1,041	2,300	$636	9,500	$378
650	$1,011	2,400	$626	10,000	$371
700	$984	2,500	$617	10,500	$364
750	$959	2,750	$596	11,000	$358
800	$937	3,000	$577	12,000	$347
850	$916	3,250	$560	13,000	$337
900	$897	3,500	$545	14,000	$328

Trace Evidence Analysis

Figure 16: Efficient Frontier for Trace Evidence Analysis—Average Total Cost v. Caseload

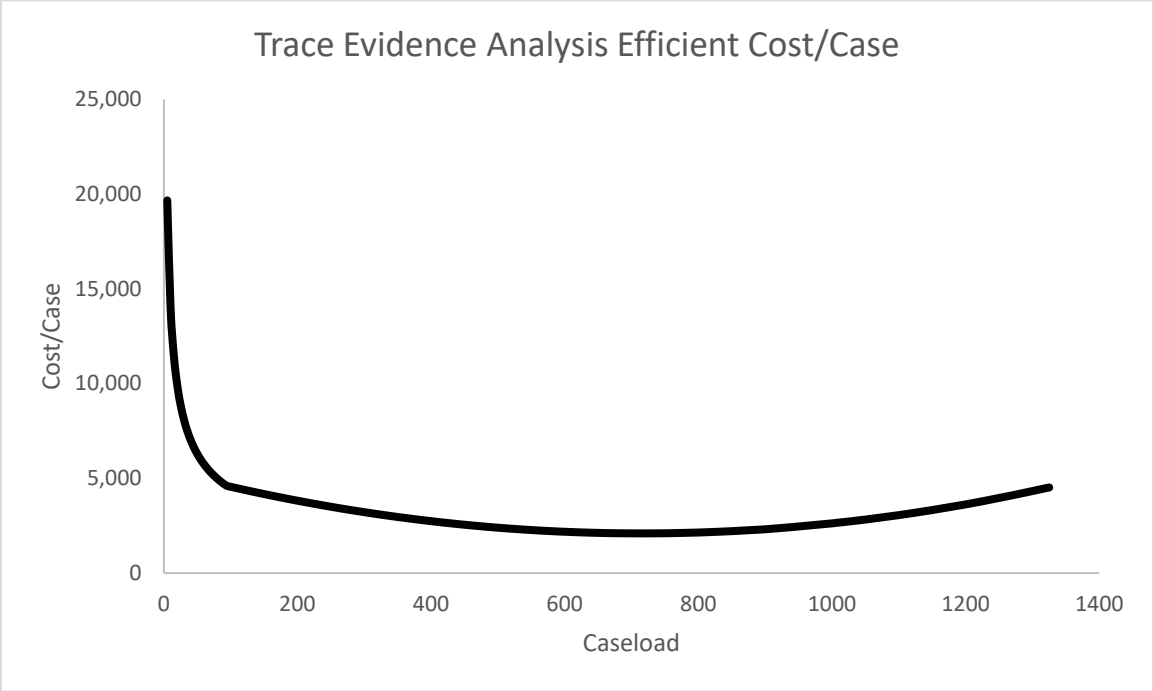

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Table 42: Efficient Frontier for Trace Evidence Analysis—Efficient Cost/Case for Various Caseloads

Caseload	Trace Evidence Analysis Efficient Cost/Case	Caseload	Trace Evidence Analysis Efficient Cost/Case	Caseload	Trace Evidence Analysis Efficient Cost/Case
5	$19,663	135	$4,282	380	$2,824
10	$13,948	140	$4,244	390	$2,782
15	$11,410	145	$4,207	400	$2,740
20	$9,895	150	$4,170	410	$2,700
25	$8,859	160	$4,097	420	$2,661
30	$8,094	170	$4,026	430	$2,623
35	$7,499	180	$3,955	440	$2,587
40	$7,019	190	$3,887	450	$2,551
45	$6,621	200	$3,819	475	$2,469
50	$6,285	210	$3,753	500	$2,396
55	$5,995	220	$3,688	525	$2,330
60	$5,742	230	$3,624	550	$2,272
65	$5,519	240	$3,562	575	$2,223
70	$5,320	250	$3,500	600	$2,181
75	$5,141	260	$3,441	625	$2,148
80	$4,979	270	$3,382	650	$2,123
85	$4,832	280	$3,325	675	$2,106
90	$4,697	290	$3,269	725	$2,096
95	$4,594	300	$3,214	775	$2,119
100	$4,554	310	$3,161	825	$2,175
105	$4,514	320	$3,109	875	$2,263
110	$4,474	330	$3,058	925	$2,383
115	$4,435	340	$3,009	1,025	$2,722
120	$4,396	350	$2,961	1,125	$3,191
125	$4,358	360	$2,914	1,225	$3,789
130	$4,320	370	$2,869	1,325	$4,518

FORESIGHT Glossary

assistant / analyst	An individual carrying out general casework examinations or analytical tests under the instruction of a Reporting Scientist or Reporting Analyst and who is able to provide information to assist with the interpretation of the tests.
backlog	Open cases that are older than 30 days.
case - institute case	A request from a crime lab "customer" that includes forensic investigations in one or more investigative areas.
case - area case	A request for examination in one forensic investigation area. An area case is a subset of an institute case.
Case – as reported in the LabRat form	Cases reported in LabRat are “area cases”
casework	All laboratory activities involved in examination of cases.
casework time	Total FTE´s for operational personnel in an investigation area (in hours) subtracted by the hours of R&D and, E&T and support and service given to external partners.
crime	Perceived violation of the law that initiates a case investigation.
direct salary	Compensation paid to employees, including salary, overtime, vacation salary, bonuses, etc.
facility expense	Sum of rents, cleaning and garbage collection, security, energy, water, communication, ICT infrastructure and facility maintenance.
floor area	Total of all floor area including office, laboratory and other.
full-time equivalent (FTE)	The work input of a full-time employee working for one full year.
full-time researcher	A forensic scientist whose primary responsibility is research and who is not taking part in casework.
investigation area	Area limited by item type and methods as they are listed in the ”definitions of investigative areas tab.
investment expense	Purchases of equipment, instruments, etc. with a lifetime longer than one year (alternatively capital expenses).
item	A single object for examination submitted to the laboratory. Note: one item may be investigated and counted in several investigation areas.
laboratory area	Floor area used for forensic investigation, including sample and consumable storage rooms.
non-reporting manager	An individual whose primary responsibilities are in managing and administering a laboratory or a unit thereof and who is not taking part in casework.

office area	Floor area of offices (square feet).
operational personnel	Personnel in operational units providing casework, research and development (R & D), education and training (E & T) and external support services. Non-reporting unit heads are included.
other floor area	Floor area of space not belonging to laboratories or offices, i.e. corridors, lunch corners, meeting rooms, etc. (square feet).
personnel expense	Sum of direct salaries, social expenses (employer contribution to FICA, Medicare, Workers Comp, and Unemployment Comp), retirement (employer contribution only towards pensions, 401K plans, etc.), personnel development and training (internal or external delivery, including travel), and occupational health service expenses (employer contribution only).
report	A formal statement of the results of an investigation, or of any matter on which definite information is required, made by some person or body instructed or required to do so.
reporting analyst	An analyst responsible in non-complicated cases (e.g. simple drugs analysis) for performing the examination of the items submitted, interpreting the analysis results, writing the analysis report and, if necessary, providing factual evidence for the court.
reporting scientist	The forensic scientist responsible in a particular case for performing or directing the examination of the items submitted, interpreting the findings, writing the report and providing evidence of fact and opinion for the court.
representation expense	The costs for hosting guests: lunches, dinners, coffees offered by the lab, and giveaway to guests or during visits abroad, etc.
sample	An item of evidence or a portion of an item of evidence that generates a reportable result.
scientist in training	An individual with no reporting rights being trained to become a reporting scientist.
support personnel	Forensic laboratory staff providing various internal support services. Management and administration personnel not belonging to the operational units are included.
test	An analytical process, including but not limited to visual examination, instrumental analysis, presumptive evaluations, enhancement techniques, extractions, quantifications, microscopic techniques, and comparative examinations. This does not include technical or administrative reviews.

Turn-around time	The number of days from a request for examination in an investigative area until issuance of a report. (Note that an area case may have multiple requests and each new request has a separate turn-around time.)
workload	Total time spent on all work related to job, including overtime.

Definitions: Investigative Areas

Blood Alcohol	The analysis of blood or breath samples to detect the presence of and quantify the amount of alcohol.
Crime Scene Investigation	The collection, analysis, and processing of locations for evidence relating to a criminal incident.
Digital evidence - Audio & Video	The analysis of multimedia audio, video, and still image materials, such as surveillance recordings and video enhancement.
DNA Casework	Analysis of biological evidence for DNA in criminal cases.
DNA Database	Analysis and entry of DNA samples from individuals for database purposes.
Document Examination	The analysis of legal, counterfeit, and questioned documents, excluding handwriting analysis.
Drugs - Controlled Substances	The analysis of solid dosage licit and illicit drugs, including pre-cursor materials.
Evidence Screening & Processing	The detection, collection, and processing of physical evidence in the laboratory for potential additional analysis.
Explosives	The analysis of energetic materials in pre- and post-blast incidents.
Fingerprint Identification	The development and analysis of friction ridge patterns.
Fire analysis	The analysis of materials from suspicious fires to include ignitable liquid residue analysis.
Firearms and Ballistics	The analysis of firearms and ammunition, to include distance determinations, shooting reconstructions, NIBIN, and toolmarks.
Forensic Pathology	Forensic pathology is a branch of medicine that deals with the determination of the cause and manner of death in cases in which death occurred under suspicious or unknown circumstances.
Gun Shot Residue (GSR)	The analysis of primer residues from discharged firearms (not distance determinations).
Marks and Impressions	The analysis of physical patterns received and retained through the interaction of objects of

	various hardness, including shoeprints and tire tracks.
Serology/Biology	The detection, collection, and non-DNA analysis of biological fluids.
Toxicology, ante-mortem	Toxicology involves the chemical analysis of body fluids and tissues to determine if a drug or poison is present in a living individual, to include blood alcohol analysis (BAC). Toxicologists are then able to determine how much and what effect, if any, the substance might have had on the person.
Toxicology, post-mortem	Toxicology involves the chemical analysis of body fluids and tissues to determine if a drug or poison is present in a deceased individual. Toxicologists are then able to determine how much and what effect, if any, the substance might have had on the person.
Trace Evidence	The analysis of materials that, because of their size or texture, transfer from one location to another and persist there for some period of time. Microscopy, either directly or as an adjunct to another instrument, is involved.

Project FORESIGHT Publications

FORESIGHT: A Business Approach to Improving Forensic Science Services, *Forensic Science Policy & Management: An International Journal* Volume 1, Issue 2, 2009, Max M. Houck, Richard A. Riley, Paul J. Speaker, & Tom S. Witt, pages 85-95

Abstract: Managers of scientific laboratories see themselves as scientists first and managers second; consequently, they tend to devalue the managerial aspects of their jobs. Forensic laboratory managers are no different, but the stakes may be much higher given the importance of quality science to the criminal justice system. The need for training and support in forensic laboratory management has been recognized for many years, but little has been done to transition the tools of business to the forensic laboratory environment. FORESIGHT is a business-guided self-evaluation of forensic science laboratories across North America. The participating laboratories represent local, regional, state, and national agencies. Economics, accounting, finance, and forensic faculty provide assistance, guidance, and analysis. The process involves standardizing definitions for metrics to evaluate work processes, linking financial information to work tasks, and functions. Laboratory managers can then assess resource allocations, efficiencies, and value of services—the mission is to measure, preserve what works, and change what does not. A project of this magnitude for forensic laboratories has not been carried out anywhere.

Key Performance Indicators and Managerial Analysis for Forensic Laboratories, *Forensic Science Policy & Management: An International Journal* Volume 1, Issue 1, 2009, Paul J. Speaker, pages 32-42

Abstract: Forensic laboratories generate a great deal of data from casework activities across investigative areas, personnel and budget allocations, and corresponding expenditures. This paper investigates ways in which laboratories can make data-driven managerial decisions through the regular extraction of key performance indicators from commonly available data sources. A laboratory's performance indicators can then be compared to peer laboratory performance to search for best practices, determine in-house trends, manage scarce resources, and provide quantitative support for the justification of additional resources.

The Decomposition of Return on Investment for Forensic Laboratories, *Forensic Science Policy & Management: An International Journal* Volume 1, Issue 2, 2009, Paul J. Speaker, pages 96-102

Abstract: For forensic laboratories, a detailed understanding of return on investment (ROI) is necessary for routine assessment, consideration of new legislative alternatives, and cost-benefit analysis for decision making. Converting performance data to ratio measures provides useful comparisons between an individual laboratory and the standards for excellence for the industry; these measures also permit an evaluation across time. Unfortunately, these same ROI measures are subject to abuse when overemphasis on a single measure leads to unintended consequences. In this paper, the ROI measure is broken down into various parts that can be tracked on a regular basis to reveal how a laboratory achieves its results. The tradeoffs between return and risk, efficiency, analytical process, and market conditions are outlined. The end product is a series of easily monitored metrics that a laboratory director may examine on a regular basis for continuous improvement.

Benchmarking and Budgeting Techniques for Improved Forensic Laboratory Management, *Forensic Science Policy & Management: An International Journal* Volume 1, Issue 4, 2010, Paul J. Speaker & A. Scott Fleming, pages 199-208

Abstract: Forensic laboratories are not immune from downturns in the worldwide economy. Recession and economic slowdowns, when coupled with the public's heightened sense of the capabilities of forensic science, put stress on the effectiveness of forensic laboratories. The resources available to forensic laboratories are limited, and managers are under greater pressure to improve efficiency and effectiveness. To this end, the use of internal and external financial and accounting metrics to plan, control, evaluate, and communicate performance is examined. Using data from the QUADRUPOL and FORESIGHT studies, we illustrate the use of external benchmarking through a calculation of laboratory return on investment and the internal development and use of a budget to enhance laboratory performance in light of limited resources.

Forensic Science Staffing: Creating a Working Formula, *Forensic Science Policy & Management: An International Journal* Volume 2, Issue 1, 2011, Joyce Thompson Heames & Jon Timothy Heames, pages 5-10

Abstract: The key issue facing forensic labs is "the classic economic problem—how to allocate limited resources with increasing demand for services, while maintaining high quality standards" (Speaker 2009). Employees are the biggest expense and most valuable resource that forensic labs possess, thus the question arises as to how to maximize human resource functions to best allocate resources through personnel. As the search is on to look for better practices to improve the operations as well as technical expertise of labs, human capital management is crucial to that objective. The purpose of this article is to process map some of the staffing issues facing forensic science labs, whether public or private, and to identify metrics from the FORESIGHT study (Houck et al. 2009) that might help lab directors create a working formula to better manage staffing (e.g., recruiting and selection) issues.

Managing Performance in the Forensic Sciences: Expectations in Light of Limited Budgets, *Forensic Science Policy & Management: An International Journal* Volume 2, Issue 1, 2011, Hilton Kobus, Max Houck, Paul J. Speaker & Richard Riley, pages 36-43

Abstract: For forensic service providers worldwide, the demand for high-quality services greatly outpaces available resources to meet those requests. The gap between the demand for services and the resource-restricted supply of those services has implications for managing performance: the effectiveness and efficiency of forensic science. The effectiveness of forensic science is directly related to the quality of the scientific analysis and the timeliness with which that analysis is provided, while efficiency is associated with attempts to minimize costs without negatively impacting quality. An inevitable result of the demand and supply gap is a backlog that results in downstream effects on timeliness, service, and quality. One important strategy to respond to the demand-supply imbalance is continual process improvement. Collaborative benchmarking as a basis for process improvement is another approach. This paper discusses the disjunction between perceived and actual value for forensic services and the rationale for providers to evaluate, improve, and re-tool their processes toward continual improvement given limited resources.

Strategic Management of Forensic Laboratory Resources: From Project FORESIGHT Metrics to the Development of Action Plans, *Forensic Science Policy & Management: An International Journal* Volume 2, Issue 4, 2011, Jonathan Newman, David Dawley, & Paul J. Speaker, pages 164-174

Abstract: The project FORESIGHT stated objectives begin with the development of metrics applicable to the activity of forensic science laboratories. These metrics enable a laboratory to assess how they fit within the forensic science industry and offer a glance at the levels of performance that they might be able to achieve. FORESIGHT's mission goes on to state the intent for laboratories to use those measurements to "preserve what works, and change what does not" (Houck et al. 2009, p. 85). This paper addresses the strategic implications of those additional aspects of the FORESIGHT mandate with a view of the strategic planning process for a forensic science laboratory. The keys to the development of an ongoing strategic planning and execution process are outlined, and then the actions of one laboratory, Ontario's Centre of Forensic Sciences, are examined to demonstrate the move from metrics to action. While there cannot yet be made a claim of "best practices," this Canadian example offers some guidance to "better practices" in the quest for continual improvement in the provision of forensic science services.

The Power of Information, *Forensic Magazine* April 10, 2012, Tom S. Witt & Paul J. Speaker

Abstract: When it comes to cost, the Foresight model was designed to overlook nothing. When we talk about the cost of doing something, we look at everything from equipment, telecommunications, heating, lighting, facility rent … everything. If a participant doesn't have access to the data, we can estimate those costs from other labs in our studies. We come up with an all-inclusive figure that tells participants what it costs to process a case. This leads to informed decisions. Take trace evidence cases, for example. You might find that processing one trace evidence case costs the same as processing two, three, or even four traditional DNA cases. While trace evidence is wonderful and powerful, if DNA alone will get you where you need to be, this cost factor will heavily affect your decision-making process. Foresight is not about cutting where it matters. It's about using resources wisely so that labs can do more and enhance the services they provide. Once you know the key metrics, you can make informed decisions.

Is Privatization Inevitable for Forensic Science Laboratories?, *Forensic Science Policy & Management: An International Journal* Volume 3, Issue 1, 2012, William McAndrew, pages 42-52

Abstract: Given the recent global recession, many national governments have been forced to implement austerity measures, and the forensic science industry has not been immune from such changes. Proposals to privatize some or all aspects of forensic science services have been bantered about for decades, but the recent economic climate has brought this idea back to the forefront of public debates. Although privatization has been shown to have many benefits in the provision of other goods and services, the idea of privatizing forensic services has been harshly criticized by scholars and practitioners. This paper explores some of those criticisms through the lens of economics, and arguments are offered regarding why market approaches in forensic science may be more successful than might have originally been imagined under certain conditions. On the other hand, recognition of those economic forces and reaction by forensic laboratories to address inefficiencies may provide the effective delivery of forensic services that forestalls privatization efforts.

The Balanced Scorecard: Sustainable Performance Assessment for Forensic Laboratories, *Science and Justice* Volume 52, 2012, Max Houck, Paul J. Speaker, Richard Riley, & A. Scott Fleming, pages 209-216.

Abstract: The purpose of this article is to introduce the concept of the balanced scorecard into the laboratory management environment. The balanced scorecard is a performance measurement matrix designed to capture financial and non-financial metrics that provide insight into the critical success factors for an organization, effectively aligning organization strategy to key performance objectives. The scorecard helps organizational leaders by providing balance from two perspectives. First, it ensures an appropriate mix of performance metrics from across the organization to achieve operational excellence; thereby the balanced scorecard ensures that no single or limited group of metrics dominates the assessment process, possibly leading to long-term inferior performance. Second, the balanced scorecard helps leaders offset short term performance pressures by giving recognition and weight to long-term laboratory needs that, if not properly addressed, might jeopardize future laboratory performance.

Efficiency and the Cost Effective Delivery of Forensic Science Services: In-Sourcing, Out-Sourcing, and Privatization, *Forensic Science Policy & Management: An International Journal* Volume 3, Issue 2, Chris Maguire, Max Houck, Robin Williams, & Paul J. Speaker, pages 62-69

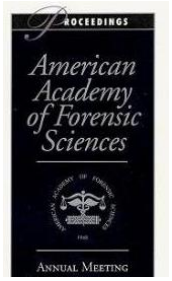
Abstract: Given the recent global recession, many national governments have been forced to implement austerity measures, and the forensic science industry has not been immune from such changes. Proposals to privatize some or all aspects of forensic science services have been bantered about for decades, but the recent economic climate has brought this idea back to the forefront of public debates. Although privatization has been shown to have many benefits in the provision of other goods and services, the idea of privatizing forensic services has been harshly criticized by scholars and practitioners. This paper explores some of those criticisms through the lens of economics, and arguments are offered regarding why market approaches in forensic science may be more successful than might have originally been imagined under certain conditions. On the other hand, recognition of those economic forces and reaction by forensic laboratories to address inefficiencies may provide the effective delivery of forensic services that forestalls privatization efforts.

Enhancing Employee Outcomes in Crime Labs: Test of a Model, *Forensic Science Policy and Management: An International Journal* Volume 3, Issue 4, 2012, David Dawley.

Abstract: This paper developed and tested a model identifying determinants of employee turnover intentions and desirable performance behaviors, including helping others and engaging in knowledge sharing. Data collected from 798 employees at ten FORESIGHT laboratories suggest that job satisfaction and embeddedness are the primary antecedents of turnover intentions and knowledge sharing, and that embeddedness is a stronger predictor variable of both outcomes. Embeddedness is driven by the employees' understanding of the lab's strategic vision. Moreover, job satisfaction and embeddedness are positively associated with helping behavior. Finally, we identified job autonomy as a primary determinant of job satisfaction. We discuss practical implications of these findings for managers.

Forensic Science Service Provider Models: Data-Driven Support for Better Delivery Options, *Australian Journal of Forensic Sciences* Volume 45, Issue 2, 2013, Paul J. Speaker.

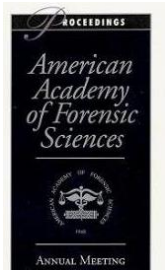
Abstract: There are a variety of models for the delivery of forensic science analysis in service to the justice system. In answer to the question as to whether there is a 'best' option for the delivery of forensic science services, New Zealand's Institute of Environmental Science and Research (ESR) has been offered as a model which demonstrates a comparative advantage over the delivery of forensic services in more traditional models. The support for that assertion rests in the ability of the ESR to react at the speed of business and avoid bureaucratic drag found too often in the public sector. This efficiency argument addresses one dimension of the search for 'best' delivery. The second dimension involves the discovery of the optimal scale of operation to take efficiency and turn it into cost effectiveness.



Improving the Effectiveness of Forensic Service: Using the Foresight Project as a Platform for Quality, *Proceedings of the American Academy of Forensic Sciences,* Volume XIX, Max M. Houck, Jay W. Henry, and Paul J. Speaker, February 2013, p.21.

Abstract: Forensic service providers are—in essence—non-profit, production-oriented organizations staffed largely by knowledge workers. Forensic scientists as knowledge workers take evidence and data and convert them into knowledge in the form of reports and testimony. They specialize in these transactions and, therefore, simplify them for the benefit of the criminal justice system; the investigators or attorneys do not need to find numerous individuals to conduct the specific examinations required for a case. As long as the costs of providing these services externally do not exceed the costs of their internal provision, for example, by a government forensic laboratory, then the organization can prosper. If the government laboratory costs are greater than the cost of finding private laboratories to provide services, then the organization may be reevaluated. Comparatively, non-profit and for-profit organizations are similar in some ways (money is an input for both) yet different (money, in the form of profits, is an output only for the private sector). Non-profits must therefore measure success in other ways, such as "low cost" or "cost effective." Forensic service providers and their parent organizations use terms such as "cost-effective" vaguely without reference to other disciplines which use these as well-defined technical terms in evaluative phrases or formulae. Despite the great concern and administrative angst over forensic service

providers' "performance" and "capacity," these metrics go undefined as industry standards.



Determinants of Turnover Intentions, Helping, and Knowledge Sharing in Crime Laboratories, *Proceedings of the American Academy of Forensic Sciences,* Volume XIX, David Dawley, February 2013, p.230.

Abstract: Forensic scientists are knowledge workers and are a laboratory's single greatest enduring expense. Therefore, it is imperative for forensic managers to find ways to retain employees, share knowledge, and create a cohesive, coherent team perspective. Based on a discussion with a group of FORESIGHT forensic laboratory directors in 2011, four major areas of research interest were identified: (1) reducing employee turnover; (2) increasing employees' helping behaviors with colleagues; (3) knowledge sharing among employees; and, (4) creating and disseminating a strategic vision to all employees.

Are Forensic Science Services Club Goods? An Analysis of the Optimal Forensic Science Service Delivery Model, *Forensic Science Policy and Management: An International Journal* Volume 3, Issue 4, 2012, William P. McAndrew, pages 151 – 158.

Abstract: Forensic science has been described as a public good by practitioners, legal professionals, and scholars, many of whom were suggesting that forensic science is simply something good for the public. It would indeed be difficult to argue otherwise. In an economic sense, the concept of a public good is defined differently from this colloquial meaning, however, leading to confusion in discussions between forensic scientists and business consultants concerning how to evaluate laboratory performance and ultimately consider strategic change from an economic or efficiency perspective. This article discusses what economists mean by a public or private good, with an application using the forensic science industry. Forensic science is likely neither a purely public or purely private good, but rather a club good that contains a degree of both the public and private. When calculated, the degree of publicness of this club good will aid in determining the appropriate institutional framework from which to provide forensic science services, as well as its optimal jurisdiction size and production level.

The Effects of Politics on Job Satisfaction in Crime Lab Employees, *Forensic Science Policy and Management: An International Journal* Volume 3, Issue 4, 2012, David Dawley & Timothy P. Munyun, pages 159 – 164.

Abstract: This study examined the effects of crime lab workers' perceptions of intra-lab politics on job satisfaction. In addition to finding that political behavior reduces employee job satisfaction, the study also identified ways in which crime lab managers can mitigate the negative effects of political behavior, increasing employee job satisfaction when political behavior is high within a given unit. Data collected from 874 employees at twelve FORESIGHT laboratories suggest that increasing crime lab worker job autonomy, job efficiency, strategic vision, and task significance are especially effective interventions that increase job satisfaction when political behavior is high. We discuss practical implications of these findings for crime lab managers. The purpose of this paper is to investigate how perceived political behavior affects the job satisfaction, or morale, of crime lab workers. The study was motivated by several interactions we had with forensic crime lab managers at the 2013 American Society of Crime Lab Directors (ASCLD) meeting. In ASCLD human resources and FORESIGHT meetings, we received consistent inquiries concerning the potential role of organizational politics as a detrimental factor on employee attitudes. These conversations highlight the unfortunate ubiquity of political behavior at work, including work in crime labs. Organizational politics often create disharmony among employees and can negatively affect employee job satisfaction and other attitudes (Breaux et al. 2009; Ferris et al. 1996). Thus, we sought to explore how political behavior affects the job satisfaction of crime lab employees, and potential managerial strategies that could be useful in mitigating for this potential negative effect.

Expanding Budgets via Strategic Use of Leasing, *Forensic Science Policy and Management: An International Journal,* Volume 3, Issue 4*, 2012,* William P. McAndrew & Paul J. Speaker, pages 169 - 179.

Abstract: An examination of the budgets of forensic laboratories reveals an unused or underused tool at the disposal of forensic laboratories. Equipment leasing offers an opportunity for a unilateral increase in the purchasing power of existing laboratory budgets and an immediate response to austerity measures. Rather than react to budget tightening with reductions in force, shared furloughs, or the forfeiture of unfilled positions, a laboratory director can forestall such measures and even see an effective increase in disposable income through a planned use of operating leases. If a public

laboratory makes an equipment purchase, the cost to the laboratory will be the full list price from the equipment supplier. However, when a private laboratory makes the same equipment purchase, it pays the supplier the full list price, but is able to deduct the expense from its income when it calculates its corporate income tax and ends up with a final expense, net of taxes, that is considerably less than the cost to the public laboratory. Leasing offers the opportunity for a private entity to purchase equipment and pass on some of the tax savings to the public laboratory through an operating lease. In this manuscript the leasing gains are explained and accompanied by a detailed example to illustrate the potential magnitudes of the gains. In this example, a representative laboratory is shown to experience nearly a twenty-five percent gain from the lease compared to the expense of a direct purchase

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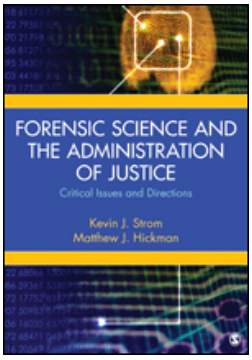

Developing New Business Models for Forensic Laboratories, Chapter 13 in *Forensic Science and the Administration of Justice*, Kevin J. Strom & Matthew J. Hickman editors, Max M. Houck & Paul J. Speaker, April 2014.

Abstract: Forensic service providers inhabit a unique, central place in the criminal justice system. Stakeholders in the forensic enterprise abound, from law enforcement to attorneys to the courts and even the public they all serve. The public orientation of these services and stakeholders necessitates forensic managers rely on providing sound performance at a reasonable cost. Certainly, the laboratory's jurisdiction will judge them on criteria such as accuracy, timeliness, and cost. Too much emphasis on quantitative outcomes, however, can create an imbalance that ignores longer-term issues, such as quality and value. Thus, efficiency, the extent to which time and effort are used to produce the desired outcome, can be mistaken for effectiveness, the attainment of that desired outcome, but they are intimately connected.

A Novel Approach to Forensic Molecular Biology Education and Training: It's Impact on the Criminal Justice System, *Australian Journal of Forensic Sciences* 47 (2), 182 – 193, 2015, Khalid M. Lodhi, Robert L. Grier, and Paul J. Speaker.

Abstract: The managers of crime laboratories face significant hurdles when preparing new hires to become productive members of the laboratory. New hires require six months of training/experience in the crime laboratory before becoming a productive member of the Biology (DNA) section. To address this deficiency in forensic DNA education, a novel forensic education curriculum was developed and tested for three consecutive years in the forensic science program at Fayetteville State University, Fayetteville, NC. The curriculum used a CTS proficiency kit which is the same kit used to validate the proficiency of forensic scientists in crime laboratories in the US. A cost benefit analysis suggests that training students in a classroom instead of in a crime laboratory provides both direct savings to the laboratory and significant societal savings as more DNA profiles are entered into the database. The societal benefit from the combined reduction in the amount of training in a crime laboratory and increasing the number of DNA database profiles entered into a database suggests a societal saving of $8.28 million for each of these months of reduced training.

鑑識科學綜論
FORENSIC SCIENCE REVIEW

A Review of Forensic Science Management Literature, *Forensic Science Review 27*, Max M. Houck, William P McAndrew & B. Daview, 2015, 53-68.

Abstract: The science in forensic science has received increased scrutiny in recent years, but interest in how forensic science is managed is a relatively new line of research. This paper summarizes the literature in forensic science management generally from 2009 to 2013, with some recent additions, to provide an overview of the growth of topics, results, and improvements in the management of forensic services in the public and private sectors. This review covers only the last three years or so and a version of this paper was originally produced for the 2013 Interpol Forensic Science Managers Symposium and is available at *interpol.int*.

Financial Management of Forensic Science Laboratories: Lessons from Project FORESIGHT 2011-2012, *Forensic Science Policy and Management: An International Journal 6(1-2),* Paul J Speaker, 2015.

Abstract: Critical to the decision-making within an individual forensic science laboratory is an understanding of their efficiency and effectiveness. The NIJ-funded project, FORESIGHT, applies financial management techniques to avowed public sector goals and offers a common starting point for the comparison of individual forensic laboratories to the established standards in the industry through a review of financial ratios. Such ratios adjust for size differences and allow insight into several aspects of the operation including evaluation of efficiency, quality, risk, market nuances, and return on investment. This study offers insight into the financial performance, productivity, efficiency, and effectiveness of forensic science laboratories. Using data from the National Institute of Justice's Project FORESIGHT for 2011-2012, a variety of benchmark performance data is presented with analytical insight into the nature of that performance. The tabular and graphic presentations offer some insight into the current status of the forensic science industry in general and provide a basis by which individual laboratories may begin to assess their own performance with respect to both analytical efficiency and cost effectiveness.

Forensic Laboratory Financial Management, *ASCLD Crime Lab Minute,* Paul J. Speaker, July 2015.

Abstract: The National Institute of Justice's Office of Justice Programs has supported laboratories for the last several years with analysis of performance via Project FORESIGHT. Project FORESIGHT has collected data from the 2006 fiscal year, growing from a handful of laboratories to over 100 participating laboratories in the most recently completed fiscal year. There is no cost to participants, and all forensic laboratories are invited to join the program. In return for data submissions, each laboratory receives a customized report comparing their performance in each forensic investigative area to the industry standards obtained from the project.

Project FORESIGHT and Return on Investment: Forensic Science Laboratories and Public Health Laboratories, *Forensic Science Policy and Management: An International Journal 8(1-2)*, Paul J Speaker, 2017.

Abstract: Project FORESIGHT developed business guided metrics for use by forensic science laboratories. Since the introduction of the project nearly a decade ago, much has been learned about the efficiency and effectiveness of the forensic laboratory industry and laboratory management has been forewarned and forearmed as they develop strategic initiatives to deal with the economic problem of limited resources available for a seemingly unlimited demand for services. The success of forensic science laboratories in the application of best practices has not gone unnoticed. Public health laboratories face similar problems and the laboratories in that industry have joined forces through the Association of Public Health Laboratories and the Centers for Disease Control and Prevention to follow the guidance of Project FORESIGHT and develop business metrics to improve the efficiency and effectiveness of this public sector service. In this paper, the project development process is highlight towards an expanded set of outcomes that offers insight into efficiency and effectiveness and connects that performance to societal outcomes through development of return on investment metrics for the industry.

National versus Local Production: Finding the Balance between Fiscal Federalism and Economies of Scale, *Public Finance Review*, pages 1-23, William P. McAndrew, 2017.

Abstract: Public finance and public choice economists have contrasting views on the determinants of public sector size. This article makes a unique contribution to this literature by exploring an integer count of output, rather than the commonly used dollar approximation of output, using data that are homogeneous across the levels of

government, where a unit of observation is not a governing body, but rather a service provider. Specifically, this article explores the counteracting effects of fiscal federalism and economies of scale using data from the National Institute of Justice with an application of data envelopment analysis and stochastic frontier analysis. I determine that provision of forensic science services at the national level rather than local level does not lead to higher relative cost, and national production may be relatively more efficient. In general, however, neither locally nor nationally operated laboratories are operating at an efficient scale, a potential argument for privatization, insourcing, or outsourcing.

Process Improvement and the Efficient Frontier: Forecasting the Limits to Strategic Change across Crime Laboratory Areas of Investigation, *Forensic Science Policy & Management: An International Journal 8 (3-4),* 109-127, Paul J Speaker, 2017.

Abstract: Undertaking programs for process improvement, such as Lean Six Sigma, permit a laboratory to do more with their limited resources. The Netherlands Forensic Institute (NFI) embraced a Lean Six Sigma change process that led to dramatic increases in capacity, while simultaneously reducing turnaround time (TAT) to a fraction of their historical experience. As other laboratories adopt similar process improvement programs, will those laboratories also experience similar results with higher productivity across the laboratory and reduced turnaround time in every area of scientific investigation? We demonstrate that similar success may be expected with a laboratory's current caseload, but the degree of improvement is related to the size of the political jurisdiction, crime rates, and the resulting caseload; and the degree of inefficiencies at the start of the process improvement program. An understanding of the economic forces at play enables laboratory management to better forecast outcomes and plan for the eventualities. Using data from Project FORESIGHT 2015–2016, tables are provided that permit laboratories to match their caseload within each area of investigation to the forensic laboratory standard for efficiency at that caseload.

Strategic leadership through performance management: FORESIGHT as PerformanceStat, *Australian Journal of Forensic Sciences,* 1-11, Max M Houck, 2017.

Abstract: Unlike the private sector, no single overarching metric exists to evaluate public sector performance. Without concepts such as profit, it can be difficult for government agencies to be accountable to stakeholders. Unless organizations have a clear strategy that holds performance to account, the organization can become pathological and never truly succeed. Momentum has been building towards evidence-based evaluations and management in government, inspired by the use of evidence-based decision-making, made popular by Michael Lewis' book Moneyball. This article presents a platform for adopting the forensic version of 'moneyball', the FORESIGHT Project, as a strategic tool to set metrics as goals, develop ways to achieve them, and improve the performance of public forensic service providers