# Safety in Forensic Science

BOAZ SANGERO*

ABSTRACT

*Using DNA comparisons, the Innocence Project has shown that people are occasionally convicted based on flawed forensic science evidence. A National Academy of Sciences (NAS) report determined many areas of forensic science lack sufficient scientific foundation, and the forensic science system does not function properly and must undergo significant changes. These changes should stem from interdisciplinary thinking, a combination of current scientific knowledge, NAS recommendations, and the law, together with advanced safety methods. To minimize the injustice of false convictions based on flawed forensic science evidence, this Article recommends applying the Systems-Theoretic Accident Model and Process (STAMP) safety model to forensic science evidence and using it in the criminal justice system in general. The Article provides detailed implementation suggestions.*

TABLE OF CONTENTS



## I. INTRODUCTION

Based on DNA comparisons, the Innocence Project has shown that innocent people are occasionally convicted based on flawed forensic science evidence.[1]

* Professor of Law, School of Law, Sapir Academic College, and Head of the Institute for Safety in the Criminal Justice System, Western Galilee College, Israel. I thank Prof. Rinat Kitai-Sangero, Justice Prof. Alex Stein, Dr. Daniel Hartmann, Prof. Nancy Leveson, Adv. James M. Doyle, Dr. Itiel Dror, Prof. Alon Harel, Dr. Ilana Schlesinger, Dr. Mechael Kanovsky, Gabriel Lanyi and Jayden Kitai-Sangero for constructive comments on earlier drafts of this paper.

[1] *See Exonerate the Innocent*, INNOCENCE PROJECT, https://innocenceproject.org/exonerate [https://perma.cc/X9G7-EF5Y].

In 2009, the NAS reported many types of forensic science evidence lack sufficient scientific foundation and recommended the forensic science system undergo significant changes.[2] According to a report by the U.S. President's Council of Advisors on Science from 2016, many of the improvements suggested in the 2009 NAS report have not been implemented.[3] This article suggests that interdisciplinary thinking is needed to minimize false convictions based on flawed forensic science evidence. This interdisciplinary thinking includes combining scientific knowledge, adopting the NAS recommendations, and adapting current laws, all based on advanced safety theory and methods.

## II. FALSE CONVICTIONS BASED ON FLAWED FORENSIC SCIENCE EVIDENCE

Scientific evidence has been expected to improve the accuracy of criminal law.[4] Although DNA testing and fingerprint comparison are considered circumstantial evidence, they are substantially more accurate than traditional or direct evidence, including the testimony of eyewitnesses and confessions by the defendant.[5] Despite the enhanced accuracy of forensic science, the Innocence Project reported the misapplication of forensic findings is the second largest contributor to wrongful convictions, accounting for 45% of DNA exoneration cases.[6] As of August 2021, the National Registry of Exonerations has logged 2,842 exonerations since 1989.[7] Of these, 688 cases (24%) were caused by false or misleading forensic evidence.[8]

---

[2] *See generally* NAT'L RSCH. COUNCIL, STRENGTHENING FORENSIC SCIENCE IN THE UNITED STATES: A PATH FORWARD (2009) [hereinafter NAS 2009 Report].

[3] EXEC. OFF. OF THE PRESIDENT, PRESIDENT'S COUNCIL OF ADVISORS ON SCI. & TECH., FORENSIC SCIENCE IN CRIMINAL COURTS: ENSURING SCIENTIFIC VALIDITY OF FEATURE-COMPARISON METHODS 7 (Sept. 2016) [hereinafter REPORT TO THE PRESIDENT].

[4] *See generally* NAS 2009 Report, *supra* note 2.

[5] Boaz Sangero & Mordechai Halpert, *Why a Conviction Should Not Be Based on a Single Piece of Evidence: A Proposal for Reform*, 48 JURIMETRICS J. 43, 69 n.135 (2007) [hereinafter *Why a Conviction*] (quoting People v. Ford, 606 N.E.2d 690, 693(Ill. App. Ct. 1992)); *see also* Mark Findlay & Julia Grix, *Challenging Forensic Evidence – Observations on the Use of DNA in Certain Criminal Trials*, 14 CURRENT ISSUES IN CRIM. JUST. 269, 272 (2003). *See generally* Keith A. Findley & Michael S. Scott, *The Multiple Dimensions of Tunnel Vision in Criminal Cases*, 2006 WIS. L. REV. 291.

[6] *Misapplication of Forensic Science*, INNOCENCE PROJECT, https://innocenceproject.org/?causes=misapplication-forensic-science [https://perma.cc/NM82-GQTZ].

[7] *% Exonerations by Contributing Factor*, NAT'L REGISTRY OF EXONERATIONS, https://www.law.umich.edu/special/exoneration/Pages/ExonerationsContribFactorsByCrime.aspx [https://perma.cc/N7DN-5GWD].

[8] *Id.* The exonerations are only the tip of the iceberg, as a result of the "hidden accident principle" in criminal law, and the rate of false convictions is estimated to be at least 5%. Boaz Sangero & Mordechai Halpert, *A Safety Doctrine for the Criminal Justice System*, MICH. ST. L. REV. 1293, 1314–19 (2011) [hereinafter *A Safety Doctrine*].

The *Daubert* ruling made it the responsibility of judges to keep nonscientific evidence (misrepresented as scientific) out of the courtroom.[9] *Daubert* specified four admissibility criteria for scientific evidence: (a) it must be based on a method that adheres to Karl Popper's principle of falsifiability; (b) it must have a known error rate; (c) the method must be published in a peer-reviewed publication; and (d) the method must be accepted by the scientific community in question.[10]

Nevertheless, judges and jurors alike are often blinded by the aura of science and, as a result, tend to overestimate the probative strength of scientific evidence.[11] Because they usually lack scientific discernment, judges rely on expert witnesses to interpret the results of forensic tests for them. When a court admits without scientific justification a certain type of evidence as scientific, it sets a precedent that other courts are liable to follow, making that type of evidence admissible for many years to come. This is how microscopic comparisons of bite marks on skin, shoeprints, and hair—widely regarded today as junk science[12]—made their way into the courtrooms over the years.

Except for DNA testing, where the probability of a random match is slight, every other type of test can produce a random match.[13] Additionally, both labs and experts are susceptible to errors in their results and interpretations (including with DNA testing[14]), even when test protocols have been followed.[15] Indeed, errors are the underlying cause of many false convictions.[16] But because of the undue weight ascribed to scientific evidence, the possibility of error in lab testing is generally ignored.[17]

Often, the scientific evidence that experts present in court is considered irrefutable, and every identification of a person is treated as definitive. This is based on the premise that every individual is unique, a conjecture that is not

---

[9] Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 592–94 (1993).

[10] *Id.*; KARL R. POPPER, CONJECTURES AND REFUTATIONS: THE GROWTH OF SCIENTIFIC KNOWLEDGE 33–37 (1963).

[11] *See generally* Michael J. Saks & Jonathan J. Koehler, *The Coming Paradigm Shift in Forensic Identification Science*, 309 SCI. 892, 895 (2005).

[12] *Overturning Wrongful Convictions Involving Misapplied Forensics*, INNOCENCE PROJECT, https://www.innocenceproject.org/overturning-wrongful-convictions-involving-flawed-forensics/ [https://perma.cc/WGA3-YY4H]; NAS 2009 Report, *supra* note 2, at 7; Brandon L. Garrett & Peter J. Neufeld, *Invalid Forensic Science Testimony and Wrongful Convictions*, 95 VA. L. REV. 1, 20, 72, 94–95 (2009). *See generally* Adam Deitch, *An Inconvenient Tooth: Forensic Odontology Is an Inadmissible Junk Science when It Is Used to "Match" Teeth to Bitemarks in Skin*, 5 WIS. L. REV. 1205 (2009).

[13] *See, e.g.*, *Why a Conviction*, *supra* note 5, at 43–45.

[14] *See generally* Simon A. Cole & Alex Biedermann, *How Can a Forensic Result Be a "Decision"? A Critical Analysis of Ongoing Reforms of Forensic Reporting Formats for Federal Examiners*, 57 HOUS. L. REV. 551 (2020).

[15] William C. Thompson, *Tarnish on the 'Gold Standard': Recent Problems in Forensic DNA Testing*, CHAMPION Jan.–Feb. 2006 at 10, 10–14.

[16] *Overturning Wrongful Convictions Involving Misapplied Forensics*, *supra* note 12.

[17] Simon A. Cole, *More than Zero: Accounting for Error in Latent Fingerprint Identification*, 95 J. CRIM. L. & CRIMINOLOGY 985, 1034 (2005).

supported by empirical data, except in the case of DNA comparisons.[18] Based on the premise of "uniqueness," forensic scientists may attest to certain identification in court, without having conducted rigorous data collection and incidence calculation based on a proven methodology. According to Saks and Koehler, "the time is ripe for the traditional forensic sciences to replace antiquated assumptions of uniqueness and perfection with a more defensible empirical and probabilistic foundation."[19] Forensic experts systematically violate the fundamental principles of science, according to which probabilistic and quantitative estimates must be based on solid methodology and anchored in empirical data.[20] Courts are often misled by the language experts use when testifying.[21]

The 2009 NAS report, *Strengthening Forensic Science in the United States: A Path Forward*, found substantial improvements are needed for the forensic science system to function properly.[22] For example, forensic lab workers allegedly conduct scientific testing, but the report found that many lack adequate training and academic knowledge.[23] The mission of forensic science is to serve the law, but to do so properly; a series of organizational and structural upgrades are needed, in areas such as training, qualifications, best practices, and the accreditation of laboratories.[24] The NAS report recommends academic research to investigate absence in the scientific knowledge of forensic sciences workers.[25]

There is an imbalance of power between prosecution and defense regarding the scientific evidence presented in court. Most of the evidence is presented by the prosecution,[26] and judges tend to ascribe greater weight to the testimony of expert witnesses for the prosecution than to the testimony of witnesses for the defense.[27]

Generally, forensic laboratories are not autonomous entities; rather, they are part of the law-enforcement system, operating with police and prosecution.[28] Laboratory personnel cooperate closely with police investigators and prosecutors, which casts doubt over their independence and objectivity.[29] Given the close coupling between forensic labs and law-enforcement agencies, it is not

---

[18] Saks & Koehler, *supra* note 11.

[19] *Id.*

[20] Garrett & Neufeld, *supra* note 12, at 19.

[21] Jonathan J. Koehler, *Linguistic Confusion in Court: Evidence from the Forensic Sciences*, 21 J.L. & POL'Y 515, 515 (2013).

[22] NAS 2009 Report, *supra* note 2, at 14–19.

[23] *Id.* at 15.

[24] *Id.*

[25] *Id.* at 27–28.

[26] According to an empirical study, court-appointed defense attorneys hire experts in only 2% of their felony cases and in only 17% of their homicide cases. *See* Findley & Scott, *supra* note 5, at 333.

[27] Garrett & Neufeld, *supra* note 12, at 89–93.

[28] *See* NAS 2009 Report, *supra* note 2, at 13, 19.

[29] *See id.* at 17–19.

unreasonable to suspect that pressure is applied on lab personnel to produce evidence in support of the prosecution. Police investigators are also in a position to supply lab personnel with details that may be irrelevant to the forensic tests being performed, but may bias test results by reinforcing a general perception of a suspect's guilt.[30] There have been reports of instances where lab workers were encouraged to conduct only tests that were likely to incriminate the suspects, and not those that may prove their innocence or incriminate someone else.[31]

Studies on criminal prosecution found forensic labs have been fostering a nonscientific subculture aimed at serving the needs of the investigators. These labs cultivate a scientific image to persuade the courts of their reliability, although the results they produce are often ambiguous.[32] The Houston Crime Lab, for example, systematically provided erroneous results for years that led to many false convictions.[33] But the Houston Crime Lab is not an exceptional "rotten apple," but rather one example within a pervasive phenomenon.[34]

Many types of evidence that forensic science presents in court have not been vetted by scientists because they were developed specifically for solving crimes (e.g., comparisons of marks left at the scene of the crime with those made by objects or body parts of the defendant, microscopic comparisons of fibers, ear print analysis).[35] This type of evidence, which is presented as proof, is not based on scientific methodology, supported by theory, or anchored in appropriate data repositories.[36] This evidence is generally collected by forensic experts who are part of the law enforcement system intended to solve crimes.[37]

The 2009 NAS report evaluated the scientific basis for every type of forensic evidence and determined that "[w]ith the exception of nuclear DNA analysis . . . no forensic method has been rigorously shown to have the capacity to consistently, and with a high degree of certainty, demonstrate a connection between evidence and a specific individual or source."[38] Therefore, a significant reform is needed.

---

[30] *See generally* Itiel E. Dror, *Biases in Forensic Experts*, 360 SCI. 243 (2018).

[31] Garrett & Neufeld, *supra* note 12, at 81–83.

[32] Saks & Koehler, *supra* note 18, at 893.

[33] MICHAEL R. BROMWICH, FRIED, FRANK, HARRIS, SHRIVER & JACOBSON LLP, FINAL REPORT OF THE INDEPENDENT INVESTIGATOR FOR THE HOUSTON POLICE DEPARTMENT CRIME LABORATORY AND PROPERTY ROOM 5 (June 2007), http://www.hpdlabinvestigation.org/reports/070613report.pdf [https://perma.cc/2SN4-BKYR].

[34] BRANDON L. GARRETT, CONVICTING THE INNOCENT—WHERE CRIMINAL PROSECUTIONS GO WRONG 90 (2011).

[35] *See* NAS 2009 Report, *supra* note 2, at 7.

[36] *Id.*

[37] *See* Beatrice Schiffer & Christophe Champod, *Judicial Error and Forensic Science: Pondering the Contribution of DNA Evidence*, *in* WRONGFUL CONVICTION: INTERNATIONAL PERSPECTIVES ON MISCARRIAGES OF JUSTICE 33, 39 (C. Ronald Huff & Martin Killias eds., 2008).

[38] NAS 2009 Report, *supra* note 2, at 7.

## III. MODERN SAFETY

Forensic science, as well as the criminal justice system in general, should be categorized as what is known in safety engineering a "safety-critical system."[39] False convictions, like the crashes of combat planes, are system errors, and like plane crashes, cause enormous damages and costs.

In aviation, the original safety approach was one of "fly-fix-fly." According to this method, planes continued to fly until an accident occurred, whereupon they would investigate the cause of the accident, fix the defect, and let the plane fly until the next accident.[40] As planes became significantly more expensive because of the advanced technologies they incorporated, this method became inadequate. Learning from experience became too costly, and an entirely new approach to safety, "identify-analyze-control," emerged over 70 years ago and replaced the "fly-fix-fly" method.[41] Its objective was to prevent accidents before they occur: "first-time-safe."[42] Modern safety identifies hazards systematically, analyzes and assesses them, and controls them with necessary measures.[43] A critical element is that of risk assessment, which provides the data needed to prioritize hazards, assesses whether the associated risks are acceptable, and allocates the resources needed to manage the risks.[44]

Methods of modern safety have spread from aviation to a variety of other fields, including transportation, engineering, labor, and medicine.[45] Modern safety systems are based on the understanding that the safety of individual components alone, separate from the system as a whole, cannot achieve system safety. These systems emphasize safety education and training, conduct routine professional risk assessments, and deploy perpetual improvement programs.[46]

To develop adequate safety methods, an organizational safety culture must be instituted with the participation of employees and management and include extensive communication between them. Management must display safety

---

[39] Mordechai Halpert & Boaz Sangero, *From a Plane Crash to the Conviction of an Innocent Person: Why Forensic Science Evidence Should Be Inadmissible Unless It Has Been Developed as a Safety-Critical System*, 32 HAMLINE L. REV. 65, 70 (2009); *A Safety Doctrine*, *supra* note 8, at 1304–05.

[40] HAROLD E. ROLAND & BRIAN MORIARTY, SYSTEM SAFETY ENGINEERING AND MANAGEMENT 8–9 (1990).

[41] *Id.*

[42] RICHARD A. STEPHANS, SYSTEM SAFETY FOR THE 21ST CENTURY 51 (2004).

[43] U.S. AIR FORCE, SYSTEM SAFETY HANDBOOK (July 2000), https://www.acqnotes.com/Attachments/AF_System-Safety-HNDBK.pdf [https://perma.cc/59BE-78EQ].

[44] *Id.*

[45] *A Safety Doctrine*, *supra* note 8, at 1296.

[46] NANCY G. LEVESON, ENGINEERING A SAFER WORLD: SYSTEMS THINKING APPLIED TO SAFETY 7–14 (2011).

leadership and nurture a culture of learning, best practices, and accepting responsibility rather than laying blame.[47]

Following the lead of engineering and aviation, modern safety demands that not only accidents be reported but also incidents (or near-accidents), which can develop into accidents.[48] The investigation of incidents is a critical component of safety. Forensic science laboratories should also be required to report incidents, such as the mistaken substitution of samples. Such reports would make it possible for safety committees to investigate errors and incidents and to recommend solutions (within a non-blaming process).[49]

Another important modern safety method is redundancy, which reduces the likelihood that the failure of a single component leads to a complete system failure.[50] For their mission-critical systems, high-reliability organizations resort to duplication of critical components (e.g., using backup computers) and personnel (e.g., assigning more than one employee to perform safety checks).[51]

A final key principle of safety is the permanent pursuit of improvement and ongoing effort to increase safety and reduce hazard.[52] Thus, as soon as safety goals are reached, higher goals are adopted.

## IV. APPLYING THE STAMP SAFETY MODEL TO FORENSIC SCIENCE EVIDENCE

According to the Systems-Theoretic Accident Model and Process (STAMP model) developed by Nancy Leveson, the safety of complex systems cannot be entrusted to traditional safety methods.[53] To engineer safer systems, Leveson proposed shifting the emphasis from component *reliability* to system *control*. STAMP begins by examining the system to determine its safety *constraints*, within the limits of which the system can operate without mishaps.[54] For example, a safety constraint in a subway system is "door must be capable of opening only after train is stopped and properly aligned with platform unless emergency exists."[55] Devising similar constraints for forensic science will not only help prevent false convictions, but also increase the likelihood of identifying the perpetrators of crimes. Next, hierarchical *control* structures need

---

[47] JAMES REASON, MANAGING THE RISKS OF ORGANIZATIONAL ACCIDENTS 195 (1997).

[48] STEPHANS, *supra* note 42, at 23.

[49] James M. Doyle, *Learning from Error in American Criminal Justice*, 100 J. OF CRIM. L. & CRIMINOLOGY 109, 130 (2010).

[50] LEVESON, *supra* note 46, at 91.

[51] Nancy Leveson et al., Effectively Addressing NASA's Organizational and Safety Culture: Insights from Systems Safety and Engineering Systems 1 (Mar. 2004) (unpublished manuscript), http://sunnyday.mit.edu/papers.html [https://perma.cc/6YAY-DEJP].

[52] STEPHANS, *supra* note 42, at 51–52.

[53] *See* LEVESON, *supra* note 46, at 4.

[54] *Id.* at 58–60.

[55] *Id.* at 192.

to be established to ensure that the safety constraints required for the system are enforced.

Hazard analysis investigates accidents before they occur. Leveson demonstrates that STAMP is better suited than traditional hazard analysis for complex systems, and for detecting human and software errors, system design errors, as well as organizational and management flaws.[56] Leveson's insight is of particular relevance to forensic science because many of its failures, together with most failures in the criminal justice system, are not the result of technical errors, but rather, a result of human errors or of organizational and management flaws.

This article proposes applying the STAMP safety model to forensic science evidence as part of the criminal justice system.[57] The recommendations of the NAS report are integrated into the STAMP table below. According to the 2016 Report to the President, many recommendations have still not been implemented.[58] The other recommendations in the table, as well as the use of the application of the STAMP framework to the NAS recommendations, are original contributions of the present article (unless otherwise referenced).

[56] *Id.* at 101.

[57] For applying STAMP to other types of criminal evidence, see generally Boaz Sangero, *Safety from False Confessions*, 54 CRIM. L. BULL. 25 (2018); Boaz Sangero, *Applying the STAMP Safety Model to Prevent False Convictions Based on Eyewitness Misidentifications*, 83 ALB. L. REV. 931 (2020).

[58] REPORT TO THE PRESIDENT, *supra* note 3, at 7. Several improvements to forensic science are recommended by the National Institute of Standards and Technology (NIST). *Forensic Science*, NAT'L INST. OF STANDARDS & TECH., https://www.nist.gov/topics/forensic-science [https://perma.cc/J3GN-CXCV]. Many additional improvements are still needed. *See generally* Cole & Biedermann, *supra* note 14; Brandon L. Garrett, *The Costs and Benefits of Forensics*, 57 HOUS. L. REV. 593 (2020).

TABLE: APPLYING THE STAMP SAFETY MODEL TO FORENSIC SCIENCE EVIDENCE ('FSE')
(All quotations in this table are from the NAS 2009 Report).[59]

| **HAZARDS** | **SAFETY CONSTRAINTS & CONTROLS** |
|---|---|
| Hazard A:<br><br>**Flawed**<br><br>**forensic**<br><br>**science**<br><br>**evidence** | *Safety constraints*<br>1. FSE must be valid and reliable.<br>2. Forensic science (FS) must adhere to "a national code of ethics."<br>3. Any device used to produce FSE must be developed as a safety-critical system.[60]<br>4. Flawed FSE must not be used by the police or the prosecution.<br>*Controls*<br>5. "Removing all public forensic laboratories and facilities from the administrative control of law enforcement agencies."[61]<br>6. Best practice protocols—both general and specific (for DNA or fingerprint comparisons, etc.) must be developed, published and enforced on all forensic laboratories (including: mandatory accreditation, components redundancy, and personnel redundancy, the duty of incident reporting, and non-blaming safety committees for investigating accidents and incidents, and recommending solutions).<br>7. Legislators should enact regulations regarding the development of forensic equipment. Manufacturers of forensic scientific equipment and forensic labs must be subject to safety regulations similar to the FDA regulations in force for medical equipment manufacturing. This regime should impose a duty to report both accidents and incidents.<br>8. Legislators should formulate rules for the admissibility of evidence produced by forensic devices in criminal proceedings, requiring that the devices be developed and supervised as safety-critical systems.<br>9. Development of research regarding the validity of forensic methods and accuracy of forensic analyses and data collection, specifically, "transforming three important feature-comparison methods that are currently subjective— |

[59] NAS 2009 Report, *supra* note 2.
[60] *See* Halpert & Sangero, *supra* note 39, at 70.
[61] NAS 2009 Report, *supra* note 2, at 24.

| | |
|---|---|
| | latent fingerprint analysis, firearms analysis, and . . . DNA analysis of complex mixtures—into objective methods."[62]<br>10. Development of research "on human observer bias and sources of human error in forensic examinations."[63]<br>11. All lab tests must be "double-blind."[64]<br>12. Laboratory personnel should receive only the minimal information required for performing the testing and no additional details about the suspect (optimally, they should not even know that the sample has been taken from a suspect) or about the case that are likely to bias them in performing the test.<br>13. All [FS] practitioners and supervisors must be professionally trained.<br>14. "A culture of science and research" should be established and encouraged among FS practitioners and supervisors (encouraging independence, openness, objectivity, error management, and critical review).[65]<br>15. A culture of safety should be encouraged among FS lab workers, police investigators, and prosecutors.<br>16. Transparency and disclosure: both the prosecution and the defense will be entitled to full access to the FSE and to the underlying data related to the case.[66]<br>17. FS practitioners and supervisors, police investigators, and prosecutors must be instructed about the hazards of violating guidelines 1–16.<br>18. Further and more specific recommendations for improving FSE should be developed by the Safety in the Criminal Justice System Institute (proposed by the author[67]) or by the "National Institute of Forensic Science" (suggested in NAS 2009 report), and in the meantime, by the National Institute of Standards and Technology (proposed in Report to the President[68]). |
| Hazard B: | *Safety constraints*<br>1. FS experts' testimony must be valid and reliable. |

[62] REPORT TO THE PRESIDENT, *supra* note 3, at 15.
[63] NAS 2009 Report, *supra* note 2, at 24.
[64] *Id.*
[65] *See id.* at 39.
[66] NAT'L ASS'N OF CRIM. DEF. L., PRINCIPLES AND RECOMMENDATIONS TO STRENGTHEN FORENSIC EVIDENCE AND ITS PRESENTATION IN THE COURTROOM 11 (Feb. 2010), https://www.nacdl.org/getattachment/a17b7ca8-7172-4671-a12c-ccd599edb064/principles-and-recommendations-for-strengthening-forensic-science-in-the-courtroom.pdf [https://perma.cc/K5AZ-E6YD].
[67] Boaz Sangero, *Safe Convictions*, 30 CRIM. L.F. 375, 386–92 (2019).
[68] REPORT TO THE PRESIDENT, *supra* note 3, at 15.

| | |
|---|---|
| **Misleading testimony provided by a forensic science expert** | 2. FS experts' testimony must be consistent with "a national code of ethics."<br>3. Misleading reports or testimony by a FS expert must not be used by police or prosecution. |
| | *Controls*<br>4. All FS experts who testify in the courts must be removed from administrative control of law enforcement agencies.<br>5. Best practice protocols must be developed, published and enforced on all [FS] experts, including mandatory certification for [FS] professionals.<br>6. Development of research on "human observer bias and sources of human error in forensic examinations."[69]<br>7. All FS experts must be "professionally trained."[70]<br>8. "A culture of science and research" should be established and encouraged among FS experts (see A.14 above).[71]<br>9. A culture of safety should be encouraged among FS experts, police investigators, and prosecutors.<br>10. Transparency and disclosure (A.16 above).<br>11. The Attorney General should direct attorneys appearing on behalf of the Department of Justice to ensure that expert testimony in court about forensic feature-comparison methods meets standards for scientific validity.[72]<br>12. Where empirical studies or statistical models exist to shed light on the accuracy of a forensic feature comparison method, an examiner should provide quantitative information about error rates. In testimony, examiners should always clearly state that errors can and do occur because of similarities between features and possible human mistakes in the laboratory.[73]<br>13. FS experts, police investigators, and prosecutors must be instructed about the hazards of violating guidelines 1–12. |

[69] NAS 2009 Report, *supra* note 2, at 24.
[70] *Id.* at 57.
[71] *Id.* at 39.
[72] REPORT TO THE PRESIDENT, *supra* note 3, at 18–19.
[73] *Id.* at 19.

| | |
|---|---|
| | 14. A prosecutor must not present in court a forensic expert testimony that was obtained in violation of guidelines 1–12.<br>15. When a court finds that an expert has knowingly given misleading testimony, the expert should be barred from appearing in courts as an expert again (after the expert had an opportunity to appeal). |
| Hazard C:<br>**Flawed or misleading forensic science evidence is admitted in court** | *Safety Constraints*<br>1. No FSE must be admitted in court unless the prosecution can prove that it is valid and reliable.<br>2. No FSE must be admitted in court unless the prosecution can prove that it meets the four conditions set out in the Daubert ruling.[74]<br>3. Any FSE based on flawed procedures should be ruled inadmissible.<br>*Controls*<br>4. No FSE should be admitted in court if obtained in significant violation of any of the above guidelines concerning the laboratories (A 1–16) or the experts (B 1–12).<br>5. Judges must be instructed in training programs (and jury members by expert witnesses) about the hazards of violating guidelines C (1–4).<br>6. Judges should conduct a pretrial judicial inquiry whenever FSE is offered, before referring the evidence to the jury. They should apply the conditions set out in the *Daubert* ruling and act as gatekeepers, barring flawed FSE from the court.<br>7. A selection-test, which would precede the *Daubert* examination of evidence presented as scientific should be conducted: if there is no systematic scientific academic work in the relevant field (e.g. shoeprints), then the conclusion is that the evidence is not scientific.<br>8. When ruling on the admissibility of expert testimony, federal judges should take into account the appropriate scientific criteria for assessing scientific validity, including "foundational validity" and "validity as applied."[75]<br>9. When permitting experts to testify about a foundationally valid feature comparison method, judges should ensure that testimony about the accuracy of the method and the probative value of proposed identifications is scientifically valid, in that it is limited to what the |

[74] Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 592–94 (1993).
[75] REPORT TO THE PRESIDENT, *supra* note 3, at 4.

| | |
|---|---|
| | empirical evidence supports.[76] Specifically, statements suggesting or implying greater certainty are not scientifically valid and should not be permitted. (In particular, courts should never permit scientifically-indefensible claims such as: "zero," "vanishingly small," "essentially zero," "negligible," "minimal," or "microscopic" error rates; "100 percent certainty" or proof "to a reasonable degree of scientific certainty;" identification "to the exclusion of all other sources;" or a chance of error so remote as to be a "practical impossibility").[77]<br>10. Prosecutors must not present in court FSE obtained in violation of guidelines A (1–16). |
| Hazard D:<br>**A defendant is convicted based on flawed or misleading forensic science evidence** | *Safety constraints*<br>1. Convictions must not be based on a single piece of evidence because no piece of evidence can prove guilt beyond a reasonable doubt.[78]<br>2. Convictions based on FSE must have strong corroboration: independent, significant evidence that defendants committed the offenses of which they are accused.<br>*Controls*<br>3. Judges must be instructed in training workshops (and jury members by expert witnesses) about the hazards of violating safety constraints D (1–2).<br>4. Judges must be instructed in training workshops (and jury members by expert witnesses) about the possibility of flawed FSE and about the factors that affect the reliability of expert testimony.<br>5. In an appeal of a conviction, there must be scrutiny of whether all the guidelines relating to the above four hazards were followed. |

## V. CONCLUSION

The above table should not be regarded as the conclusion of this article but as the beginning of an ongoing process of improvement. To reduce the rate of false convictions based on flawed forensic science evidence, we should combine current scientific knowledge, the NAS recommendations, and the normative

[76] *Id.*
[77] *Id.*at 19.
[78] *See generally Why a Conviction*, *supra* note 5.

legal rules (while adapting them), all within the framework of advanced safety theory and methods.