The Emerging Role of the Forensic Engineer

ROGER L. BOYELL
SENIOR MEMBER, IEEE

Abstract—**Within the field of engineering is a subspecialty devoted to serving the legal profession. This paper examines the need for and the functions of the new breed of forensic engineer, who applies recognized principles of engineering toward resolution of various questions facing lawyers, judges, and juries.**

INTRODUCTION

The complexities of our society make it no surprise for an engineer to consult an attorney. More and more, however, the legal profession finds it necessary to obtain engineering services.

The forensic engineer applies the knowledge and skills of engineering to questions decided by courts of law. The word *forensic* comes from the same root as *forum*, referring to argumentation and debate. A forensic engineer may be a specialist in any branch of engineering; he or she provides expertise in engineering specifically to lawyers and judges. Although the man in the street knows the term *forensic medicine* (usually by association with a television series whose central character is a coroner), the term *forensic engineering* has not yet reached the dictionary.

Since the primary function of forensic engineering is the communication of knowledge from one sphere of activity (engineering) to another (the law), it is an appropriate subject for this journal. The purpose of this paper is to describe the work of the forensic engineer toward two goals:

- To encourage more members of the engineering profession to make available their expertise.
- To obtain recognition by the legal profession of the resources available in this regard.

The interdisciplinary nature of forensic engineering is discussed with regard to the need for forensic engineers, the environment in which they function, the procedures they implement, and the requirements on an individual serving as a forensic engineer.

Roger L. Boyell, has 30 years of diversified experience in electronic engineering. Since 1979, he has provided forensic services as a consultant and expert witness, specializing in the comprehension and conveyance of the capabilities and limitations of electronic equipment relevant to questions of law. He has made material contributions to cases involving target detection and tracking, tape recording and reproduction, and other complex electronic systems. His address is 416 Parry Drive, Moorestown, NJ 08057-2877.

THE NEED

Legal questions of liability, responsibility, and the administration of justice frequently involve properties of the physical world. These questions may be resolved by translation into engineering terms, for example:

- *Lawyer:* Was the automobile traveling too fast for the curve under the specified conditions?
  Engineer: For a given coefficient of friction and radius of curvature, what is the maximum tangential velocity that could be maintained?
- *Lawyer:* Was the radio communication system designed for dependable operation in the circumstances?
  Engineer: Does a link analysis (involving transmitter power, antenna gains, receiver threshold, propagation loss, and the like) indicate adequate margin of signal/noise ratio (or carrier/interference ratio) to account for variability in these factors to a given confidence level?
- *Lawyer:* Is the extensive damage to the machine due to defective design, improper installation, or faulty operation? That is, does liability attach to the machine vendor, the installation contractor, or the user?
  Engineer: Does the machine meet formal, agreed-on specifications; was it installed in accord with suitable codes and practices; did the operator violate standard orders or procedures? That is, precisely what went wrong, in what sequence, and why did it occur that way?

The forensic engineer is needed to translate between the legal issue and an engineering statement of the problem. Weighty legal decisions may hang on technical matters involving natural laws, calculable quantities, or adher-

0361-1434/0300-0016$01.00 ©1987 IEEE

ence to specifications. There may be significant consequences for individuals and corporations. The courts need impartial, objective evidence, presented in a formal manner. And sometimes the only such evidence is provided by an engineering analysis.

If the crux of the matter is centrifugal force, or square-law attenuation, or some other engineering matter, an engineer is needed to analyze and formulate the question in a manner that permits impartial, objective conclusions to be reached.

The engineer may have to reconstruct a sequence of events and attribute causal relationships among them. He is needed to explain the limitations imposed by nature, to interpret conformance with specifications and regulations, to perform and report on controlled experiments – to assemble and present technical evidence.

THE ENVIRONMENT

Most engineers feel that a technical proposal is the most demanding test of their skills. A good technical proposal is necessarily complete, accurate, and persuasive. Minor errors of fact or logic, or inadequate justification of results, or incomplete recitation of advantages/disadvantages are magnified by the competitive situation. For this reason, some firms devote more resources to writing proposals than to performing the jobs proposed.

The legal environment, however, is even more demanding. The resolution of disputes is intrinsically adversarial and confrontational. Any error or omission is seized by the opposition and used to attack the credibility of an argument. This is true for carefully prepared written reports as well as for live oral testimony.

Another characteristic of the environment is that the audience, although highly skilled in matters of law, is generally unlearned in the engineering matters being argued. The routine use of formulas, graphs, theorems, and calculations is foreign to judge and jury. Hence the engineer must translate the results of his analysis back to familiar concepts and familiar terminology.

"Applying the relation $f = ma$ (or $E = IR$, or $d = vt$) shows that the force (or voltage, or distance) would be.... This means, in ordinary terms, that ...." Making such a reverse translation is fraught with the dangers of oversimplification or distortion. It takes considerable skill to interpret technical relations precisely yet understandably to the nontechnical person. An adequate explanation involves a level of formality in description somewhere between two extremes:

- The mathematics of scintilation-correcting active optics
- "Twinkle, twinkle, little star"

THE PROCEDURES

A forensic engineer will usually be engaged by an attorney on behalf of his client. A period of courtship is necessary, wherein compatibility between attorney and engineer is assessed. The engineer may be asked to perform a preliminary examination of documents or study a location of an alleged crime or other incident, and to prepare a preliminary report (oral or written). Such a report is usually accompanied by phrases like, "Subject to more detailed data gathering ...." The report provides an indication of the suitability of the engineering analysis to the case.

If the engineering view is pertinent and the preliminary information is useful, the next step is for the forensic engineer to prepare a comprehensive written report. This report is a document that may be delivered to the opposing side in hope of effecting an out-of-court settlement. It may be the basis for engineering testimony presented to the court. As a formal report, it should crisply enunciate the relevant facts known, the assumptions made, the examinations conducted, the calculations performed, the results obtained, and the conclusions drawn. Although this report must withstand scrutiny by peer engineers, it should be written for the lawyer, who is obviously not versed in engineering disciplines. The logic should be unassailable, the conclusions easily understood.

In addition to standing on its own as a deliverable document, the comprehensive engineering report also provides the basis for engineering testimony. The engineer is called by the attorney as a witness in a courtroom proceeding. Usually the engineer must formally qualify as an expert in the eyes of the court. He can so qualify by relating, under oath, his education, training, and experience in the engineering disciplines involved.

The opposing attorney will attempt to refute the expert's qualifications, perhaps by pointing to some specialized aspect of the case at hand. (The author was recently disclosing his expertise in VHF radio communication, but the opposing attorney insisted that he had to qualify as an expert specifically in the use of battery-operated, handheld transceivers as used by police departments in the service of the railroad industry. The court was ultimately convinced, however, that the relevant expertise was in the propagation of radio waves, which behave the same irrespective of the size, power source, or ownership of the radio equipment.) This would-be expert must express his qualifications in a truthful manner but embracing the particulars of the case at hand. If he formally qualifies as an expert, his testimony carries weight. Hence even the engineer's expertise in his particular branch of engineering will be subject to review before the court.

When the engineer qualifies as an expert and his testimony is admitted, he will be formally questioned by the attorney who engaged him and probably cross-examined by the opposing attorney. He must exhibit all the skills of effective technical presentations – accuracy, completeness, and aptness of expression. Despite critical commentary, made in real time, he must maintain the dignity of the engineering profession. His explanations must explicitly distinguish among immutable laws of nature, the variables and tradeoffs that are embodied in electronic or other equipment, and the conclusions or opinions offered as his own.

The expert testimony goes into the record as evidence. Implicitly, however, the engineer's apparent knowledge and skill is evaluated by judge and jury. Indeed, when a lawyer first consults an engineer, he considers how that engineer will ultimately, on the witness stand, impress the court. Generally, the testimony will be the content of an engineering report, prompted by questions from the lawyer. The opposing lawyer may cross-examine the technical matters related. Eventually, all measurements, hypotheses, conclusions, and interpretations that can be expected of the engineer are aired.

At this point, he has served his purpose. (The exception is the large, complex case, for which both sides bring several experts in to testify.) Since engineering is a hard science, and since proof of an engineer's correctness usually involves testable behavior or measurable properties of the material world, competent argument is usually not disputed on engineering grounds.

Naturally, the forensic engineer can become caught up in the case and is thus likely to be interested in tracking it to a final decision or settlement. But following his court appearance and dismissal, his official work is completed. Until the next case.

REQUIREMENTS

Beside the basic requirement of competence in the engineering disciplines involved in a case, the forensic engineer must also possess ability as a writer and lecturer. Defending a technical proposal to corporate management, or elucidating a new theory to students, is easy by comparison with working in the stress environment of the adversarial courtroom. But even though the work is demanding, considerable satisfaction results from a well-delivered argument in the forum.

A basic tenet is that the argument must be objective. The engineer may not compromise his integrity and blindly support the desires of the attorney or his client. Truthful analysis is mandatory; intentional distortion or omission is a breach of principle.

For this reason, the engineer should accept compensation based only on work performed – typically at an hourly rate. Contingent fees (that is, compensation dependent on the outcome of the case) are unethical. Analyses and experiments not favorable to the client's position should nevertheless be reported. The lawyer must make the decision on what to present as evidence.

A forensic engineer must have the ability to make technical matters clear, in both written reports and oral testimony. He must be able to create simple diagrams for the judge and jury – who are not conversant with contour maps, lever diagrams, histograms, or trajectory plots. He must explain what the diagram portrays and why it is useful in visualizing the concept under discussion.

The engineer is accustomed to high-level abstractions, lengthy numerical calculations, and statistical representations. These may be necessary to perform the analysis; however, the results and conclusions must be stated succinctly. He should be so competent in his field that he is able to reduce concepts to the level of popular science magazines.

For instance, Newton's third law of motion is given meaning by visualizing the action of a blown-up balloon when its neck is released. Specular and diffuse reflection are illustrated by the mirror and the matte wall, respectively. Electric potential and current density are illustrated by the familiar (to engineers) analogy to water pressure and flow rate. Structural resonance is dramatically illustrated by the sound-shattered glass. Circular error probability is explained by a dartboard.

An effective forensic engineer will use examples like these to convey engineering concepts to the nonengineer. It is not an easy task; it requires patient, detailed, illustrated exposition.

If we perform such services well, perhaps forensic engineering will achieve wider recognition.