

# Forensic Metrology: Where Law Meets Measurements

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**Abstract** – This paper is intended to give a short overview about the emerging branch of a new forensic science called forensic metrology. It is important to highlight the role played by scientists in proceedings and the relevance of scientific rules that, in the past, were not considered at all. This is especially true when measurement uncertainty is considered, since it apparently conflicts with the legal principle of certitude. Nowadays the attitude of courts is changing because of the reached awareness of the important information brought by uncertainty in investigating an event, even though building a bridge between scientists and legal people, who refer to different backgrounds, is quite a challenge, and is hard to win.

## I. FORENSIC METROLOGY

Forensic sciences include all scientific matters useful for the ascertainment of truth in legal proceedings, such as, for instance, DNA analysis and fingerprints detection, blood analysis and other measurements useful for this purpose. It is well known that metrology is an extremely wide field, with an almost uncountable number of applications, which we can synthetically and traditionally summarize in three main areas: scientific metrology, industrial metrology and legal metrology. Considering the increasing importance that measurements are gaining in nowadays proceedings, we should also include forensic metrology and define it as that part of the measurement science aimed at supporting the trier of fact in interpreting the available scientific evidence on events involved in a trial. Of course, the final goal of searching for scientific evidence is that of providing a clearer insight in the events, so that the trier of fact is helped in finding the truth.

Obviously metrology, which is defined by the BIPM as the science of measurement, embracing both experimental and theoretical determinations at any level of uncertainty in any field of science and technology, has its rules and codes that an expert has to follow. Problems may arise when the legal rules that legal people have to follow, according to proceedings, may apparently conflict with science, especially considering the principles on which legal orders are based.

Recently, several authors from different countries have expressed the opinion that, despite the apparent conflict, metrology rules and legal rules pursue the same goal and, if properly understood and applied, may reinforce each other, thus really helping the trier of fact to ascertain the factual truth [1 – 5].

It is therefore of critical importance to briefly analyze the most relevant principles on which legal orders are based, so that the way science and law may synergistically cooperate to ascertain the truth becomes clear.

## II. LEGAL ORDERS

Historically we use to consider the two most relevant legal systems: common law and civil law. The first one is applied in countries influenced by UK, USA, Canada and other English language States, while civil law system is adopted by European countries (east and west Europe).

The *common law* system finds its origins in England in the Middle Ages, and it is in use in countries whose legal and cultural heritage can be traced back to the UK as former colonies of the British Empire.

A common law system is a legal system that gives great weight to the *body of precedents*, called the *common law*, which binds the judge's decision on the principle that it is unfair to treat similar facts differently on similar occasions. According to this principle, if a similar dispute has been resolved in the past, the court is bound to follow the same reasoning followed in the past and render the same decision as that taken in the past by the same or another court. This is referred to, with a Latin locution, as the *stare decisis* principle. If, however, the court finds that the current dispute is fundamentally different from all previous cases, it has the authority and duty to make law by creating a precedent that binds all future decisions of the same or another court on similar disputes [6].

The *civil law* system finds its origins in the legal system of the Roman Empire and is now in use in those countries which originated from the dissolution of the Roman Empire and those that can be traced back to these countries as their former colonies and hence, share the same legal and cultural heritage.

A *civil law* system has core principles that are codified

into a referable system which serves as the primary source of law. In brief, civil law proceeds from abstractions, formulates general principles, and distinguishes substantive rules from procedural rules that are generally encompassed into separate codes. Judges must refer to these rules to render their decisions and have limited authority to interpret law, although precedents can create jurisprudence.

In contrast to the common law case, courts can refer to precedents but are not bound by them. In a civil law system, referring to the same codes ensures that similar facts are not treated differently on similar occasions [7].

Despite the substantial difference between those two legal systems, related to the different references the judges are bound to and have to consider, and the different procedural rules followed by the trials, they share a common principle: the decision of the court must be the consequence of a logical line of reasoning, based on the references (in a deductive way for the common law system and an inductive way for the civil law system) and the available evidence. In any case, the line of reasoning has to be referred to the examined case and the related evidence. The logical reasoning that relates the available evidence to the case has to be strict, so that no *reasonable doubts* are left about guilt.

Furthermore the consequence of this principle is another one, that is generally referred to as the **certitude of law** principle, which aims at sanctioning similar illegal behaviors in the same way, among the other scopes. Apparently, this is an easy task, but actually it seems sometimes difficult to identify all elements of a behavior and compare them with the abstract rules that consider it as illegal. That means that sometimes a doubt could arise if a misconduct is been acted or not by the defendant: so how can we handle this doubt?

The answer to this question is implicit in the strict law requirement to prove guilt beyond any reasonable doubt, to punish someone; on the contrary, if a doubt remains, it is in any case preferable to exonerate the defendant, instead of punishing someone who could be innocent because of that uncertain circumstances.

In ancient time justice was administered by emperors and kings and it was characterized by symbols and divine signs, so the culprit was condemned on the basis of a divine proof such as walking through fire: in that case, if the culprit would have stayed alive, there would have been no doubt about his or her innocence. Luckily proceedings are nowadays based on legal process rules and on available evidence. As far as evidence is concerned, it is relevant to outline that evidence has, in law issues, a *wider meaning* than in technical matters, because it is not generally confined to *experimental evidence* only: law assigns documents, lapse of time and other circumstances a special effect on the investigated case.

However, experimental evidence, that is evidence that

can be found by means of scientific or technical knowledge, has become more and more important in nowadays court issues.

When considering the description of phenomena, it is important to emphasize that scientists and technical people are appointed to this task, that is more and more often accomplished by performing appropriate measurements. As we all know, when measurements are involved, also metrology is involved with all its elements, especially including uncertainty.

As clearly stated in the Guide to the Expression of Uncertainty in Measurement (GUM) [8], measurement uncertainty “reflects the lack of exact knowledge of the value of the measurand.” It provides a quantitative statement characterizing the dispersion of values that can actually and “reasonably be attributed to the measurand.” It is well-recognized that “the result of a measurement is only an approximation or estimate of the value of the specific quantity subject to measurement and thus the result is complete only when accompanied by a quantitative statement of its uncertainty”.

Technical people are well aware that uncertainty is a synonymous for doubt, and, therefore, measurement uncertainty expresses and quantifies the doubt about how well the result of the measurement represents the value of the quantity being measured. This means that, whenever the trier of fact bases its decision on experimental results, measurement uncertainty completes the available evidence, providing the trier of fact with a quantification of the doubt that its decision is the right one.

We can somehow conclude that metrology and justice share the same goal: the ascertainment of truth. Each discipline pursues this aim through different means that are sometimes in apparent contrast. For instance justice requires a decision to be taken *beyond any reasonable doubt*, while metrology content itself by quantifying the doubt that the measurement result does not fully represent the value of the measurand.

If we also consider the various formalities which characterize trials, we can readily understand why, most of the times, the dialogue between technical experts in measurement and legal people is difficult, because of the difference associated with the language (for instance uncertainty vs. certainty) and the rules of laws.

In fact we must consider that, in legal terms, certitude of law could influence and could persuade the trier of fact that uncertainty, considered as something doubtful, is a concept which conflicts with law and creates confusion reducing the amount of information available to the judge.

Legal people have employed a long time to understand the importance of uncertainty in measurement, as shown in the next paragraphs.

### III. SCIENCE AND LEGAL PROCEEDINGS

In the recent past, science and technology have evolved

in an impressive way, and new tools are available to help finding objective evidence about a fact. Fingerprint detection and identification techniques, vocal print identification, methods to identify the presence of blood and extracting its DNA, DNA identification methods, toxicological tests, etc. are now widely used in any investigation and in any court of justice. The relevance of measurement, and, consequently, that of metrology, is evident because, in any of the aforementioned cases, there is a need for measurement activities run by experts. As already recalled, a measurement result has to be expressed with its uncertainty, in order to comply with both technical standards and best practice and the task, assigned to scientists in legal proceedings, to discover the truth.

Luckily the concept of uncertainty which was misled in the past by law people, is becoming more understandable for the trier of fact, especially in the common law countries.

First of all it is important to remind that the trier of fact generally relies on the competence of the technical expert who conducts experimental activities and consider him or her as a "truth keeper", whenever the decision to be rendered depends, at least partially, on scientific evidence.

However, this can be considered only partially true because of the ability of scientists to describe natural events depends on the available scientific knowledge to describe that event. The body of knowledge, in every scientific field, is an always evolving entity and can only provide an approximated, sometimes very good, sometimes not, knowledge of an event. We do not need to refer the Heisenberg indetermination principle to understand that the incomplete knowledge of the physical phenomena provided by science, the non-ideal behavior of the employed instruments and the approximation with which the available primary Standards realize the measurement units do not allow us to know the exact, true value of a measurand.

The above concepts, that represent the scientific background of measurement uncertainty, have not yet been fully perceived by technical people, so we can easily understand why, in origin, measurement uncertainty was not considered in legal proceedings. It was not only because of the carelessness of the involved technical experts, but mainly because of the mistrust of legal people who had always sought certitude in science and assumed, from their point of view, that certitude could only be expressed by a single numerical value.

This opinion was though strengthened by some technical associations, as it was the case of the International Association for Identification (I.A.I.). As reported in [4], an I.A.I resolution, adopted in 1979, and related to individual identification through fingerprints, included the partial ones, or latent print, considered a professional misconduct for its members to provide

courtroom testimony describing an identification through latent prints as "possible, probable, or likely" rather than "certain."

The consequence of this resolution was that it became a widespread practice at American trials for the expert's proponent to invite the expert to testify that the expert's opinion was a scientific or medical "certainty" and the conviction that experts called to testify in a trial have to provide certainty (with a single point value) to trier of fact remained deep-rooted for a long period of time [4].

It is worth noting that the opinion expressed by the I.A.I. was not totally justified by the scientific knowledge of that time, that, even if the GUM had not yet been issued, did recognize that a measurement result could be affected by an error. However, the public opinion was so deeply convinced that scientific results were always "true", that any honest admission of a possible degree of uncertainty was considered a technical misconduct.

Recently the opinions of the scientific community has changed because of the fact that it is not possible to determine and describe phenomena with total certainty. Consequently, the legal community has been influenced by that new scientific approach which favours the scientific knowledge as imperfect, differently than in the past, during the enlightenment period, when philosophers (and scientists) thought that human brain could understand all natural events because they have a definite and rational order.

According to this new scientific awareness of uncertainty, also the approach of legal people is going to change and to improve, especially in USA where, always according to [4], some courts have assigned to the expert called to testify the role to interpret and describe measurements in terms of intervals of confidence within which the value of the measurand is expected to lie with a given probability, or taking into consideration a safety margin. This new judicial trend has taken a long time to be expressively affirmed: the first step is considered the Daubert case [4] decided by the Supreme Court where we find a very significant change in the way scientific evidence is considered, expressed by judge Blackmun's declaration: "*[I]t would be unreasonable to conclude that the subject of scientific testimony must be 'known' to a certainty; arguably there are no certainties in science.*"

This new approach opened the door to a totally different way to consider the results provided by experts as not totally certain. The consequence is that also other American lower courts (Federal Courts) began to consider more reliable those experts who testified taking into account the uncertainty or a safety margin, than others that did not [4].

This different trend has been recognized also in the scientific literature in the legal field [3, 4] that focusses on two different new trends, both related to scientific activities in legal proceedings, which depend on the different methods applied. The first one concerns the

safety margin and it lies in considering a test result with its margin of error, previously determined, with the intent of compensating the uncertainty of the result. The second approach considers, instead, the uncertainty as it is expressed in the GUM.

In this way, the scientific knowledge enters legal proceedings, at least in the USA, so that a new relationship can be built between law science, more suitable for the purpose of trials, to find truth and avoid misleading the trier of fact.

On the other hand European courts are rather far from this consciousness, as clearly inferable from the opinion expressed by a public prosecutor commenting a verdict about the (unfortunately) famous Perugia proceedings. The prosecutor stated that the expert witnesses called by the judge to analyse the DNA test ordered during the first grade trial “did not answer the questions of the court and raised doubts and stated that everything is possible” since they reported that the values measured during the test were below the uncertainty value, and therefore, it was not possible to state whether the DNA was that of the victim [1].

It is worth noting that, as usual, the trends that evolve in the USA are acknowledged in Europe after some years. So it is probable that in a not so far future European courts will adopt decisions on the basis of uncertainty (when scientific support is relevant and fatal) as it is going to happen in USA.

Furthermore we can't disregard that litigations are not only decided in courts (the matters involved in this disputes are always civil objects) but also through other means, called alternative dispute resolutions, which have the same consequence of a traditional legal proceedings, because the decision binds litigants, but they are governed entirely by parts and they follow other rules fixed sometimes by recognized associations. Moreover it is relevant to remark that legal systems include also private (allowed) orders such as those ruling sports (FIA, FIFA, UCI, IAAF, FIS, ...) and other international associations (IEEE, IMEKO, ...): those systems issue their rules and all the associated have to comply with them to avoid sanctions. Even in actions brought within that systems, scientific knowledge could play an important role in supporting judges.

A quite famous example of arbitration settled by uncertainty is that related to the disqualifications of both Ferrari F1 cars at the 1999 Malaysian Grand Prix, in Sepang. Upon checking the Ferrari cars for legality, at the end of the race, the Malaysian FIA (Fédération Internationale de l'Automobile) officers found that the dimensions of the bargeboards on both Ferrari cars were not compliant with the technical specifications, and both cars were disqualified. Ferrari appealed before the International Court of Appeal (ICA) and proved that, taking into account the uncertainty with which the bargeboards had been measured (and that was not

declared), their dimensions could have been inside the given tolerance specifications. The ICA accepted this technical explanation and points and positions earned by the Ferrari cars at the Grand Prix were reinstated.

It is worth noting that Ferrari changed the badgeboards before the following race. The explanation is that, probably, a measurement made with better accuracy would have shown that the dimensions were outside the specifications. And this gives clear evidence that measurement uncertainty must be considered when making a decision. Decreasing uncertainty decreases the doubt about how different a measured value is from a threshold value, and hence provides the trier of facts with better evidence on a fact.

#### IV. CONCLUSIONS

The considerations reported in the previous sections have shown how the correct expression of measurement results used in forensic activities can be extremely useful to the trier of fact to render equitable decisions.

In particular, measurement uncertainty plays a crucial role in providing the trier of fact with information as complete as possible on an event. Measurement uncertainty is an important piece of evidence for the trier of fact to consider and weigh with the rest of the evidence in arriving at a verdict. Absent uncertainty, part of the evidence is hidden to the trier of fact, so that a non-equitable decision may be rendered.

In this respect, uncertainty is not a “get out of jail free” card for culprits, as is sometimes considered by those people who are not familiar with this concept [5]. Uncertainty, on the contrary favours neither party, but it facilitates the discovery of truth by enabling proper interpretation of the available evidence.

For this reason forensic metrology is becoming a more and more important activity, across the technical and legal fields, and it is more and more advisable that the basic metrology principles are understood also by law people.

Luckily, courts in the USA have become aware of these principle, including measurement uncertainty. The same, unfortunately, cannot be said for the European courts. This seems to be only partly related to the different legal systems applied in the USA and Europe. It seems to be mostly due to the different way the legal system and the people who administer justice assimilate scientific findings. The European system has been historically slower in assimilating them, and this might explain the lag in considering measurement uncertainty as an important element in evaluating scientific and technical evidence.

It is therefore important that legal people and metrologists work together to understand each other needs, so that the very fundamentals of metrology can be explained to the triers of fact, as has already started in the USA with good result.

I hope that this paper may represent a first contribution in this direction.

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