DECLARATION OF ALICIA CARRIQUIRY IN SUPPORT OF DEFENDANT JOSEPH BLACKNELL'S MOTION TO EXCLUDE FIREARMS AND TOOLMARK IDENTIFICATION EVIDENCE OR, IN THE ALTERNATIVE, FOR A *KELLY* HEARING

I, Alicia Carriquiry, by my signature below, hereby declare under penalty of perjury that the following is true and correct:

1. I received an undergraduate degree in 1982 in Agricultural Engineering from the Universidad de la República Oriental del Uruguay, in Montevideo, Uruguay. In 1985 I received a Master of Science degree in Animal Breeding and Genetics from the University of Illinois at Champaign-Urbana. In 1986 I received a Master of Science degree in Statistics from Iowa State University and in 1989 I was awarded a PhD degree in Statistics/Animal Breeding and Genetics from Iowa State University. After obtaining my PhD, I joined the Department of Statistics at Iowa State University as a tenure-track Assistant Professor in 1990. I was promoted to Associate Professor with tenure in 1996 and to Full Professor in 2000. I was awarded the title of Distinguished Professor of Liberal Arts and Sciences in 2010. I am currently Associate Departmental Chair and co-Director of Graduate Education. Between 2000 and 2004 I served as Associate Provost of Iowa State University. I have been a Visiting Professor at the Catholic University of Chile (in 1993, 1996 and 2007-2008) and at Duke University (1997).

2. I am an elected member of the International Statistical Institute (ISI) and a Fellow of the American Statistical Association (ASA) and of the Institute of Mathematical Statistics (IMS). I was Vice President of the ASA and a member of the ISI Council. I have been President of the International Society for Bayesian Analysis, a member of the Executive Committee of the IMS and a member of the Board of Trustees of the National Institute of Statistical Sciences. I serve on two standing committees of the National Academy of Sciences and chair a committee of

the National Research Council (NRC). Further, I have been a member of several ad-hoc committees of the NRC and the Institute of Medicine (IOM). In particular, I was a member of the recent NRC Committee on assessing the technical feasibility of a national ballistics database. The report from the Committee, which was released in 2008, concluded that at this time, a comprehensive database, to include images of bullets and casings fired by all guns manufactured or imported into the United States, is not technically feasible. While deciding on the admissibility of firearm markings in court was not within the charge of the Committee, the practice of firearm-related toolmark examinations was discussed by the Committee. The Committee concluded that the two fundamental assumptions on which firearm marks examinations rest, those of "uniqueness" and "reproducibility" of the marks, have not been fully demonstrated and that more research is needed before that can be accomplished.

3. I was also the Principal Investigator (PI) on a research project funded by the Federal Bureau of Investigations (FBI, through the Midwest Forensic Resource Center at Iowa State University) in 1998-2000. Co-Principal Investigators were Professors Hal Stern (now Dean of the College of Science at the University of California at Irvine) and Prof. Michael Daniels (now Chair of the Department of Statistics at the University of Florida). The main objective of that research project was to assess whether an error rate (or a probability of a coincidental match) could be attached to comparative bullet lead analysis results, so that it would then be possible to quantify the probative value of bullet lead matches. We found that the probability of a match between two samples with different origin was non-negligible and that extensive research would need to be carried out before the probative value of bullet lead matches could be established. Results were reported to the FBI in a report entitled *Statistical Treatment of Trace Evidence,* submitted to FBI on May 4 of 2000. Possibly as a consequence of the findings in the report, several challenges to expert testimony on bullet lead arose. This in turn motivated the creation of

the NRC Committee which investigated issues around bullet lead evidence and the eventual cancellation of bullet lead analyses by the FBI. I was asked to make a presentation to that Committee as an expert on issues associated with the estimation of the probability of coincidental matches in trace evidence.

4. The *uniqueness* of firearm markings is an assumption that is far from being proven. Even if we were to assume that a match between two bullets or casings can be accurately established using visual inspection, the significance of the match in terms of probative value relies on the assumption that each gun leaves a "unique" impression on all bullets or casings fired with it. This is an unverified and very critical assumption. The assumption of "uniqueness" put in a different way says that if two samples match (i.e., have indistinguishable markings) then they must have a common origin. In the case of markings on casings or bullets this says that the two samples must have been fired by the same gun. To my knowledge, this assumption has not been tested in a scientifically defensible way. With the information that is currently available, it is not possible to estimate the probability that two bullets or casings will match if they were fired by *different guns*. This probability is what we call the *coincidental match probability*. It is crucial to know whether this coincidental match probability is or is not negligible in order to appropriately evaluate the probative value of the match.

5. Consider evidence such as markings on a bullet or a casing that match the markings left on a different sample fired from a known gun. In order to determine its probative value, the evidence must be evaluated under two competing hypothesis: the "common origin" hypothesis and the "different origin" hypothesis. We can, in principle, compute the probabilities of observing the evidence under the two competing hypothesis, and the ratio of the two is called the *likelihood ratio* or the *odds against no guilt*. In the case of DNA evidence, for example, it is

well known that:

- The probability that two samples will match if they were deposited by the same person (the "common origin" hypothesis) is very large.
- The probability that two samples will match if they were deposited by a different person (the "no common origin" hypothesis) is very low.

The likelihood ratio for DNA evidence is very large and thus DNA evidence has high probative value. What can we say about the probative value of bullet or casing markings? Very little. That is due to the following: while we know that the numerator in the likelihood ratio (the probability of a match given the same gun) is reasonably high (at least under the assumption that the interior of the barrel has not changed in any way), the denominator (or the probability of a match of two samples fired by different guns) is unknown and will continue to be unknown unless extensive and as yet un-conducted studies are undertaken.

6. Whether firearms examiners can accurately establish a match between two or more samples by observing the samples under a comparison microscope and counting "matching" striations is a matter of debate, even in the community of firearms examiners. (See, for example, the work by Miller which appeared in the *AFTE Journal* in Spring 2000, Spring 2001 and Winter 2004.) In his 2000 paper, Miller carried out thousands of land impression comparisons using bullets of different calibers that were known matches or known non-matches of specimens for which two and three dimensional images were available. His main objective was to establish that the less subjective approach known as CMS (Consecutive Matching Striae) produces few false positive identifications and that its performance does not depend on caliber. In his research, Miller obtained the distribution of the percentages of land impression matches (minimum, average, maximum) over the thousands of comparisons for known matches (KM) and known non-matches (KNM) samples. His results are striking in that they put into question

whether an examiner who is only counting matching land impressions can accurately declare that two samples match. Miller's results suggest that there is a similar distribution of matching impressions among bullets that are known to be matches and among bullets that are known to be non-matches. In particular, when the comparisons were carried out using 9mm bullets he found that on the average, 7% and 11% of impressions among KNM and among KM actually matched using two-dimensional images and that the corresponding average percent matches were 11% and 18% using three dimensional images. Given that in both cases, the ranges of matching landmarks overlap to a high degree, it is clear that simply by counting the number of matching markings between two samples it is not possible to accurately declare a match between the samples. Consider, for example, the data obtained by Miller for 9 mm ammunition using two-dimensional images. The range in the *number* of matching striae was 2 to 9 in KNM and was 1 to 27 in KM. The corresponding average numbers were 5 and 7. Note that even though the maximum number of matching impressions appears to be much higher in KM (27 versus 9), the relatively low average of 7 indicates that much of the distribution of the number of matching impressions was actually concentrated around the lower values. Thus, given two samples with anywhere between 2 and 10 matching impressions it would be equally likely for them to be a "true" match or a "true" non-match.

7. The existing studies performed by firearms examiners are not adequate to establish the probability of a match given that different guns fired the samples, nor are they adequate to establish an error rate for firearms examiners. Estimating the probability of a match given that different guns fired the samples is very difficult and to my knowledge has not been done. The spotty, small scope studies that have been carried out in a disjointed manner by various firearms examiners in no way can be considered to provide the information that would be needed to properly quantify the probative value of firearms markings. In order to reliably

estimate the probability of a coincidental match (or the "uniqueness" of the markings left by a gun), it is necessary to conduct a population-wide study, where a representative (or at least very large) sample of guns is tested using a wide range of ammunition under both controlled and field conditions. Given that there are currently many millions of guns in use in the United States, such an experiment would need to include several thousand guns (although the exact number would need to be determined on the basis of experimental design principles and the margin of error that would be acceptable for the results). In essence, the study would result in a "reference database" similar to the database of DNA samples that has been used to successfully establish that the probability that two matches with different origin will match is essentially zero. Thus, we argue that the fact that at this time the information to make defensible statements about "uniqueness" is not available is no reason to unjustifiably assert that in the absence of evidence to the contrary the probability of a coincidental match will be assumed to be negligible.

8. In conclusion, as the recent National Academies report on ballistic imaging states: "The validity of the fundamental assumptions of uniqueness and reproducibility of firearms-related tool marks has not yet been fully demonstrated." Experimental results reported in the forensics literature cast doubts about the claim that by simply counting the number of matching striae or other impressions it is possible to determine whether two samples match. Miller's results, based on many thousand of comparisons of samples of different calibers and captured using two and three dimensional images clearly show that there is a significant overlap in the number of matching striae and other impressions in bullets known to be matches and bullets known to be non-matches. Thus, even among firearm examiners the practice of simply counting matching impressions appears to be questionable.

Even if we were to assume (against the evidence) that matches can be accurately established by inspecting impressions, stating that markings from firearms are "unique" and thus, that a common origin conclusion can be drawn is potentially incorrect and definitely over-reaching given the current level of information that is available. It has not been shown that a gun will leave markings on the bullets it fires that are distinguishable from the markings left by *all other* guns.

It is generally accepted among statisticians that claims of identity (such as those made by firearms examiners when stating that two samples match) are inherently probabilistic. As such, these claims of identity must be supported by adequate data. In my opinion as a statistician with many years of experience, the studies that have been carried out and the (scant) data that have been collected in no way support the methods or the conclusions that are routinely drawn by firearms examiners.

Signed under penalty of perjury this _21_ day of November, 2011.

Alicia Carriquiry

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