This document has been accepted by the Academy Standards Board (ASB) for development as an American National Standard (ANS). For information about ASB and their process please refer to asb.aafs.org. This document is being made available at this stage of the process so that the forensic science community and interested stakeholders can be more fully aware of the efforts and work products of the Organization of Scientific Area Committees for Forensic Science (OSAC). The documents were prepared with input from OSAC Legal Resource Committee, Quality Infrastructure Committee, and Human Factors Committees, as well as the relevant Scientific Area Committee. The content of the documents listed below is subject to change during the standards development process within ASB, and may not represent the contents of the final published standard. All stakeholder groups or individuals, are strongly encouraged to submit technical comments on this draft document during the ASB’s open comment period. Technical comments will not be accepted if submitted to the OSAC Scientific Area Committee or Subcommittees.

Assigning Propositions for Likelihood Ratios
Foreword

When DNA testing data are generated from evidence and then compared to data from known individuals, it is necessary to provide a statistical statement for any comparison for which an individual cannot be excluded as a contributor (or possible contributor) to the DNA. One common reporting format is based upon the assignment of a likelihood ratio ($LR$):

\[
LR = \frac{Pr(E|H_1, l)}{Pr(E|H_2, l)}
\]

where:

- $E$ are the findings (e.g., DNA profile(s), presumptive test results, observations),
- $H_1$ and $H_2$ are two mutually exclusive propositions, and
- $l$ is the relevant information.

The terms $H_p$ and $H_d$ are often used in place of $H_1$ and $H_2$, and are assigned for the prosecution ($p$) and the defense ($d$), respectively. The arguments for the use of $H_1$ and $H_2$ in lieu of $H_p$ and $H_d$, respectively, relate to avoiding any unintended assignment of propositions or scenarios to individuals such as the prosecution or defense. The arguments in favor of the alternative set, $H_p$ and $H_d$, relate to directness of language. The exact propositions of the prosecution and defense may not be known, and in such circumstances, reasonable propositions consistent with both viewpoints should be selected for the analysis.

Cook et al. [5] and Evett et al. [7] classified propositions into four levels: from top to bottom these are offense, activity, source, and sub-source. This was expanded to include a sub-sub-source level and is explained in detail in Buckleton et al. [2], pp. 46-48. This document is limited to propositions at the sub-source and sub-sub-source levels.

The propositions in any given case depend on the knowledge of the case circumstances at the time the interpretation is carried out. Relevant information may include, but is not limited to, the following elements:

a) The alleged location, direction, and time of transfer  
b) The location and time that the sample was taken  
c) The genotypes of the person of interest (POI), the complainant, and proposed consensual partners, any persons who admit activity that could deposit DNA or have legitimate access to the sample, and any elimination samples such as scene of crime staff or lab staff  
d) Evidence of opportunity for alternate donors may be relevant. In particular, the genotypes, ethnicity, or relationships\(^1\) of persons who could reasonably be alternative donors is relevant. Also relevant is information of those who could not reasonably be considered possible donors because of lack of opportunity.

---

\(^1\) There is a misperception that the likelihood ratio approach is unsuitable if any individuals within the pair of propositions are related. This is not true as the likelihood ratio approach has been used for decades for paternity cases and missing persons. One could envisage two situations:  
a) The known individuals are related and have been genotyped, or  
b) One, or more, of the postulated unknown individuals is related to the genotyped individuals.
e) Information of the results of other forensic analyses that suggest the presence at the scene of an alternatedonor.

When talking about the case information, it needs to be emphasized that one does not consider information such as prior conviction, motive, or a confession of the POI as relevant forensic information for the evaluation of the DNA results.

**Keywords:** statistics, likelihood ratio, propositions, DNA, DNA interpretation
# Table of Contents

Scope .............................................................................................................................................. 1
Normative References ..................................................................................................................... 1
Terms and Definitions ..................................................................................................................... 1
Requirements .................................................................................................................................... 2
Annex A (normative) Best Practice Recommendations ................................................................. 4
Annex B (informative) Bibliography .............................................................................................. 6
Assigning Propositions for Likelihood Ratios

1 Scope

This standard is to be used by laboratories for the assignment of propositions for the interpretation of DNA profiling evidence using likelihood ratios.

2 Normative References

There are no normative references.

3 Terms and Definitions

For purposes of this document, the following definitions apply.

3.1 analysis
An interpretation and/or likelihood ratio calculation.

3.2 conditioning
The act of assuming one or more pieces of information when assigning a conditional probability. The information might be the profile of an individual, or profiles of a set of individuals, that are assumed to have contributed DNA to the evidentiary item under a particular proposition, or it might simply be the assumption that a particular proposition is true. Any events (or information) that have been used for conditioning are placed to the right of the conditioning bar in a conditional probability expression.

3.3 conditioning profile
The DNA profile of an individual assumed to be a contributor to the DNA (or DNA profile) obtained from an evidentiary item in both propositions, \( H_1 \) and \( H_2 \), of a pair of propositions.

3.4 evaluative analysis
An analysis using propositions that are used with the intent of producing an \( LR \) for reporting.

3.5 hierarchy of propositions
An organizational structure for propositions. Proposition pairs are classified by the level of information they can provide to the trier of fact: offense (e.g., “Mr. X raped V”), activity (e.g., “Mr. X had intercourse with V”), source (e.g., “The semen came from Mr. X”), sub-source (e.g., “Mr. X is a contributor to this DNA”), and sub-sub-source (e.g., “Mr. X is the minor contributor to this DNA mixture”). Further explanations can be found in Buckleton et al. [2], pp. 46-48.

3.5.1 sub-source level proposition
A proposition that specifies a defined set of assumed contributors (known or not) to the questioned DNA (evidentiary) sample.
3.5.2
sub-sub-source level proposition
A proposition that specifies an assumed contributor (known or not) to one contribution of a questioned DNA (evidentiary) mixture (e.g., the major contributor of a two-person mixture).

3.6
intimate contributor
An individual from whose body a biological evidentiary item has been directly obtained.

3.7
probabilistic genotyping
The use of biological modeling (i.e., statistical modeling informed by biological data), statistical theory, computer algorithms, and/or probability distributions, to infer genotypes and/or calculate likelihood ratios.

3.8
probabilistic genotyping system
Software, or software and hardware, which utilizes a probabilistic genotyping approach to infer genotypes and/or calculate likelihood ratios.

3.9
proposition
A statement that is true or false, associated with the standpoint of one of the parties on a disputed issue of interest.

4 Requirements

Refer to Annex A, Best Practice Recommendations, for additional normative information on the following requirements.

4.1 The laboratory shall have a documented policy that outlines the difference between relevant and irrelevant information.

4.2 The laboratory shall have a documented policy on the reporting of results within the hierarchy of propositions. The policy shall define the level within the hierarchy of propositions (e.g., sub-source or sub-sub-source) that the laboratory reports.

4.3 The laboratory shall have a documented policy defining when a conditioning profile will be used. Support for the assumption of non-intimate conditioning contributors shall be documented in the case file.

4.4 Where multiple persons of interest (POIs) have LRs that support an association to a DNA mixture, within the capabilities of the approach used, an analysis shall be performed using proposition pairs that test whether the multiple POIs can be included together in the observed DNA profile.

4.5 If an analysis requires the number of contributors to be declared for each proposition or pair of propositions tested, then the laboratory shall have a documented policy regarding the assignment of the number of contributors for each proposition or pair of propositions.
4.5.1 If an analysis requires a predefined number of contributors, then an assessment of the number of contributors shall be documented in the case file prior to comparison to any individuals who are not intimate or reasonably assumed (e.g., consensual partners) contributors.

4.5.2 If the approach used to calculate the LR cannot accommodate different numbers of contributors in $H_1$ and $H_2$, then the profile of the POI shall not be used in the initial assignment of the number of contributors.

4.5.3 Use of conditioning profiles in the contributor number assessment shall be documented in the case file.

4.5.4 If the laboratory allows for drop-in events in their probabilistic genotyping procedures, the laboratory shall have a documented policy regarding contributor number assumptions that require drop-in events.

4.5.5 Any reassessment of the number of contributors based upon a probabilistic genotyping system’s diagnostic calculations, or subsequent interpretations or LR calculations, shall be documented in the case file. This documentation shall include the reason for the change.

4.6 The laboratory shall have a documented policy on when and how propositions will include a relative of a conditioned donor within the set of unknowns.

4.7 Reporting only one, or a subset, of the LRs for evaluative analyses that have been conducted for multiple proposition pairs, differing by the conditioning profiles and/or the number of contributors, shall require documentation in the case file providing the reason the selected LRs were chosen.

4.7.1 Lacking any direction from either party, the laboratory shall formulate one or more reasonable proposition pairs that address each party’s assumed interests.

4.7.2 The laboratory shall reassess the data under a new pair of propositions if presented with a reasonable request (i.e., supported by the associated data, and presented in a timely manner) from either party regarding an alternate proposition pair.
Annex A
(normative)

Best Practice Recommendations

A.1 Within the capabilities of the analysis approach used, the laboratory should report results for a pair of propositions that addresses the issue of interest. This level is the highest level in the hierarchy for which the forensic scientist can provide information. Hence, the laboratory should report results at sub-source level rather than sub-sub-source level.

A.2 If a single source profile is deduced from the mixture, even where sub-source propositions for mixtures are possible, then a sub-sub-source proposition pair may be used. However it is permissible, and may be advisable, to continue to operate at the sub-source level.

A.3 A profile should be assigned as a conditioning profile to a mixture when an individual is identified as an intimate contributor, or when it is reasonable to assume their presence based on case specific information, and the associated data supports the assumption. The conditioning profile could be from the complainant, POI, or other individual depending on the case scenario.

A.4 When conditioning on individuals in non-intimate samples, propositions that do not condition upon that individual’s profile may also be examined. A positive log\((LR)\) value for an individual may be used as evidence of support for calculations that condition upon them.

A.5 The analysis should separate the propositions into their simplified constituents (i.e., simple proposition pairs) when an \(LR\) favoring \(H_1\) has resulted from a compound proposition pair\(^3\) incorporating multiple POIs under \(H_1\) and none of the POIs under \(H_2\), in order to establish the weighting and the consequent probative value of the evidence per contributor under \(H_1\).

A.5.1 The results of the analyses using the simple proposition pairs should be included in the report unless the compound conclusion supports exclusion.

A.5.2 A simple proposition pair may include conditioning upon each POI separately in \(H_1\), where all other contributors are treated as unknowns. This could, however, contradict the assertions of the party represented by that proposition.

A.5.3 A simple proposition pair may include conditioning upon multiple POIs in \(H_1\) and one or a subset of POIs in \(H_2\) with the goal of isolating the weight attributable to the POI not conditioned upon in \(H_2\). In the case of non-intimate samples, if a POI’s profile is assumed in both \(H_1\) and \(H_2\), then an \(LR\) shall also be calculated for a simple proposition pair with the POI not assumed in \(H_2\).

A.6 While the number of contributors to an evidentiary sample is strictly unknown, assessments of the number of contributors should involve profile traits such as

a) The number of clearly defined alleles;
b) The relative intensities of the results (e.g., relative peak heights);

\(^2\) simple proposition pair

A pair of propositions where no more than one POI in \(H_1\) is replaced with an unknown donor in \(H_2\) or vice versa.

\(^3\) compound proposition pair

A pair of propositions where more than one POI in \(H_1\) is replaced with unknown donors in \(H_2\) or vice versa.
c) The relative proportions of peaks in expected artifact positions (e.g., STR reverse stutters);
d) Any assumptions regarding the contribution of a conditioning profile’s alleles; and
e) Any assumptions regarding rare genetic traits (e.g., tri-allelic genotypes).

Probabilistic methods may be used to provide estimated probabilities for the number of contributors.

A.6.1 A number of alternatives for the number of contributors may be used.

A.6.2 The number of contributors may be the same or different for $H_1$ and $H_2$.

A.6.3 For approaches that utilize probabilities, as opposed to probability densities, the number of contributors may be assigned values that maximize the probability of the evidence separately under $H_1$ and $H_2$. In such cases, the number of contributors under each proposition need not be the same within a given likelihood ratio.

A.6.4 Assigning the number of contributors may involve assessing possible drop-in events and also assessing or specifying the number of drop-in events allowed. Typically, if more than two drop-in events would be required, the assumed number of contributors should be increased [9, 11].

A.7 Investigative analyses\(^4\) should not be reported but retained in the case file. The report may include a comment that investigative analyses have been undertaken.

\(^4\) Investigative analysis
An analysis using propositions that are used to determine the best pair(s) to use for an evaluative analysis.
Annex B
(informative)

Bibliography


14] References at www.swgdam.org