A. Purpose:

Uncertainty of Measure is a method of defining and quantifying the magnitude of the parameters associated with a process that may contribute to error, or uncertainty in that process. Since all measurements have a potential for variability; determination of the uncertainty as a process, attempts to allow users of such measurements to understand the reliability and hence suitability of the measured value for the intended use.

The Firearms section reports the uncertainty for measurements in cases where there is a "measurement that matters", specifically for firearm barrel length and overall firearm length.

B. Definitions:

1. Uncertainty of Measure [4] is a non-negative parameter associated with the result of a measurement that characterizes the dispersion of values that could reasonably be attributed to the measurand.

2. Measurement that Matters: A determined value that is used, or may reasonably be used, by an immediate or extended customer (anyone in the Judicial process) to determine, prosecute, or defend the type or level of criminal charge(s).

3. Type B Evaluation [4]: method of evaluation of uncertainty by means other than the statistical analysis of a series of observations

4. Readability: the smallest increment of the measuring device (i.e. 1/16")

5. Repeatability: closeness of the agreement between the results of successive measurements of the same item carried out under the same conditions.

6. Linearity: the quality of delivering a significantly identical sensitivity throughout the range of the measuring device.

7. Standard Uncertainty [4] (u_i): a component of uncertainty, represented by an estimated standard deviation equal to the positive square root of the estimated variance.

8. Distribution:

   a. Normal [2]: A pattern of frequency of values arrayed around a central mean value, such that the pattern is consistent with a Gaussian distribution

   b. Rectangular [2]: A distribution of values that that there is equal probability that a value lies anywhere within the interval.

9. Combined Standard Uncertainty [2]: (u_c) square root of the sum of the squares of the uncertainty factors, used to express the uncertainty of many measurement results.

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10. <u>Coverage Value</u> **(k):** when applied to the combined uncertainty allows for the definition of the confidence interval; (k = 2 allows for a 95% confidence interval, k = 3 allows for a 99% confidence interval)

11. <u>Expanded Uncertainty</u> **(U):** the interval in which a value (y) can be confidently asserted to lie

12. <u>Index</u>: demonstrates the individual factor's contribution to the event uncertainty

13. <u>Standard Deviation</u>: A value associated with a normal, or Gaussian distribution describing an average departure from the mean value.

14. <u>Measurand</u>[4]: Quantity intended to be measured.

C. **Procedure:**

The expanded uncertainty of measurement will be reported for all barrel lengths and overall firearm lengths as required. This estimation of uncertainty is determined through the use of a budget approach. The budget approach evaluates the components that contribute to the measurement uncertainty and quantifies their contribution to the whole. The Uncertainty Budget will be maintained in a laboratory notebook within the Firearms section.

The uncertainty will be determined using the following steps:

1. Define the measurement process.

    a. The Firearms unit must meet requirements of State Statute 53a-211 in regards to reporting firearm lengths and barrel lengths.

        i. The "measurand" is the barrel length and/or overall firearm length.

    b. The device used for this process is a 36 inch steel ruler attached to an "MD" measuring device, the ruler is calibrated and is NIST traceable.

        i. The NIST traceable ruler will:

            (a) Be stored and handled within the laboratory in a manner to preserve the integrity of the ruler. When transportation of the device is required the ruler will be packaged to avoid damage.

            (b) Be inspected annually by the section Supervisor or designee to assure that there is no visible change to the device; this will be recorded in the log book containing the uncertainty budget within the laboratory. No periodic checks of calibration are required due to the robustness of the device.

            (c) Will be calibrated every 5 years by an external calibration service that is accredited to ISO/IEC 17025:2005; the accreditation must be through IACC, or ILAC and the scope of accreditation must include the service needed.

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(i) Calibration of the ruler is considered a critical service and as such the Quality Section or section Supervisor will evaluate the vendor prior to assure they meet the above requirements prior to sending the device for calibration.

(ii) The service provider will be required to provide a traceability certificate (however named). This certificate will be reviewed by the Quality Section or the section Supervisor to assure that the device continues to meet the needs of the Firearms section prior to use.

(iii) In the event that no companies are available that are accredited and perform the needed service the Quality Section will work with the section Supervisor to approve a non-accredited vendor based on ASCLD/LAB International criteria.

2. Identify the components that contribute to the uncertainty.

   a. Components related to the measuring device.

      i. Scale readability
      ii. Scale resolution
      iii. Calibration uncertainty (of ruler)
      iv. Calibrated ruler error
      v. Proper use, storage and handling of ruler

   b. Components related to the analysts.

      i. Multiple analysts
      ii. Training
      iii. Experience
      iv. Visual acuity
      v. Time of day, day of week, interruptions, workload

   c. Components related to the test method.

      i. Using same method to perform test
      ii. Differences between analysts in establishing parallel position to measuring device
      iii. Differences between analysts in establishing the zero point on the measuring device

   d. Components related to the laboratory facility.

      i. Temperature variation impacting the coefficient of expansion of the measuring device
      ii. Lighting
      iii. Space

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3. Determine how much each component contributes to the whole (i.e. quantify).

4. Convert quantities to standard uncertainties.

5. Calculate combined standard uncertainty.

6. Expand the combined standard uncertainty by the coverage factor (k).

   a. (k) is 2 allowing a 95.45% probability that the reported value falls within the reported uncertainty range.

7. Evaluate the expanded uncertainty; review the obtained value to determine if it makes sense.

   a. Is the obtained expanded uncertainty so large that it is of no value (example a U that is +/- 15 inches would not be useable)

   b. Does the obtained expanded uncertainty meet the needs of the customer (the user of the report)?

      Example: too large of an uncertainty may not allow the user of the report to make determinations related to State regulations on firearm possession.

   c. Review to possibly identify calculation errors.

8. Report the uncertainty.

   a. Uncertainty will be reported in inches (or fraction of an inch).

   b. The coverage factor will be included on the report.

9. The uncertainty budget will be reevaluated/reviewed annually by the section Supervisor or designee. The review will by sufficient to determine if there has been any substantial changes to the individual components of the uncertainty budget.

   a. If there is no substantial changes the Supervisor or designee will note that the evaluation was performed, this will be stored in the laboratory notebook containing the uncertainty budget within the Firearms section.

   b. If the uncertainty needs to be recalculated and results in a new uncertainty value, the evaluation will be documented and stored in the laboratory notebook containing the uncertainty budget. Additionally the section Supervisor will inform the section members of the change.

10. The uncertainty budget will additionally be reevaluated/reviewed when any of the following occurs.

    a. New employees are assigned to casework associated to work where uncertainty is reported.

    b. A new measuring device is placed into service.

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    c. The measuring device is recertified.

11. Example of budget chart:

Measurand: Barrel Length and Overall Firearm Length				
Factor	Value (x), g	Uncertainty of the individual factors (u_i), inches	Distribution	Index (Relative contribution to u_i in %)
Readability	From manufacturer	x/distribution value	**Rectangular** (use the square root of 3 as the distribution value)	The uncertainty for the factor divided by the subtotal of the standard uncertainties $(u_i)^2/(\sum(u_i)^2)$
Repeatability #	Determined in house this is the SD determined as listed above	Since this is a normal distribution the value is the SD obtained from the calculations	**Normal** – (normal distributions needs no estimation of the value since it has been calculated)	The standard uncertainty for the factor divided by the subtotal of the standard uncertainties $(u_i)^2/(\sum(u_i)^2$
Resolution	From manufacture	x/distribution value	**Rectangular** (use the square root of 3 as the distribution value)	The standard uncertainty for the factor divided by the subtotal of the standard uncertainties $(u_i)^2/(\sum(u_i)^2$
Device Uncertainty	From Calibration Certificate (if reported as expanded uncertainty divide number by 2	x/distribution value	**Rectangular** (use the square root of 3 as the distribution value)	The standard uncertainty for the factor divided by the subtotal of the standard uncertainties $(u_i)^2/(\sum(u_i)^2$
Error of measuring device	From Manufacturer	x/distribution value	**Rectangular** (use the square root of 3 as the distribution value)	The standard uncertainty for the factor divided by the subtotal of the standard uncertainties $(u_i)^2/(\sum(u_i)^2$
Subtotal of the uncertainty $(\sum(u_i)^2)$		Sum of the square of each of the uncertainty factors		
Uc = square root of $(\sum(u_i)^2)$	Square root of the sum of the squared uncertainty components	inches		
Expanded Uncertainty (U); where (k) = 2	Uc*the coverage factor $U = (u_c x2)$	**inches**		

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This component will capture multiple uncertainty components related to analysts, the facility and the test method itself.

D. Sources of Error:

1. Not considering all components of uncertainty for the measuring process.

2. Applying the wrong type of distribution based on the data.

E. Reference:

1. Expert Trigger Pull Uncertainty article, Forensic Magazine, authors Dana Sevigny, Jeff Salyards

2. A Beginner's Guide to Uncertainty of Measurement, National Physical Laboratory United Kingdom, 2001, Author Stephanie Bell

3. [2]"NIST Reference on Constants, Units and Uncertainty" http://physics.gov/cuc/uncertainty

4. [4]International Vocabulary of Metrology – Basic and general concepts and associated terms **(VIM)** 3rd edition

5. ASCLD/LAB International "Estimating Uncertainty of Measurement Policy'

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