

Metrological Traceability

The unabridged edition...

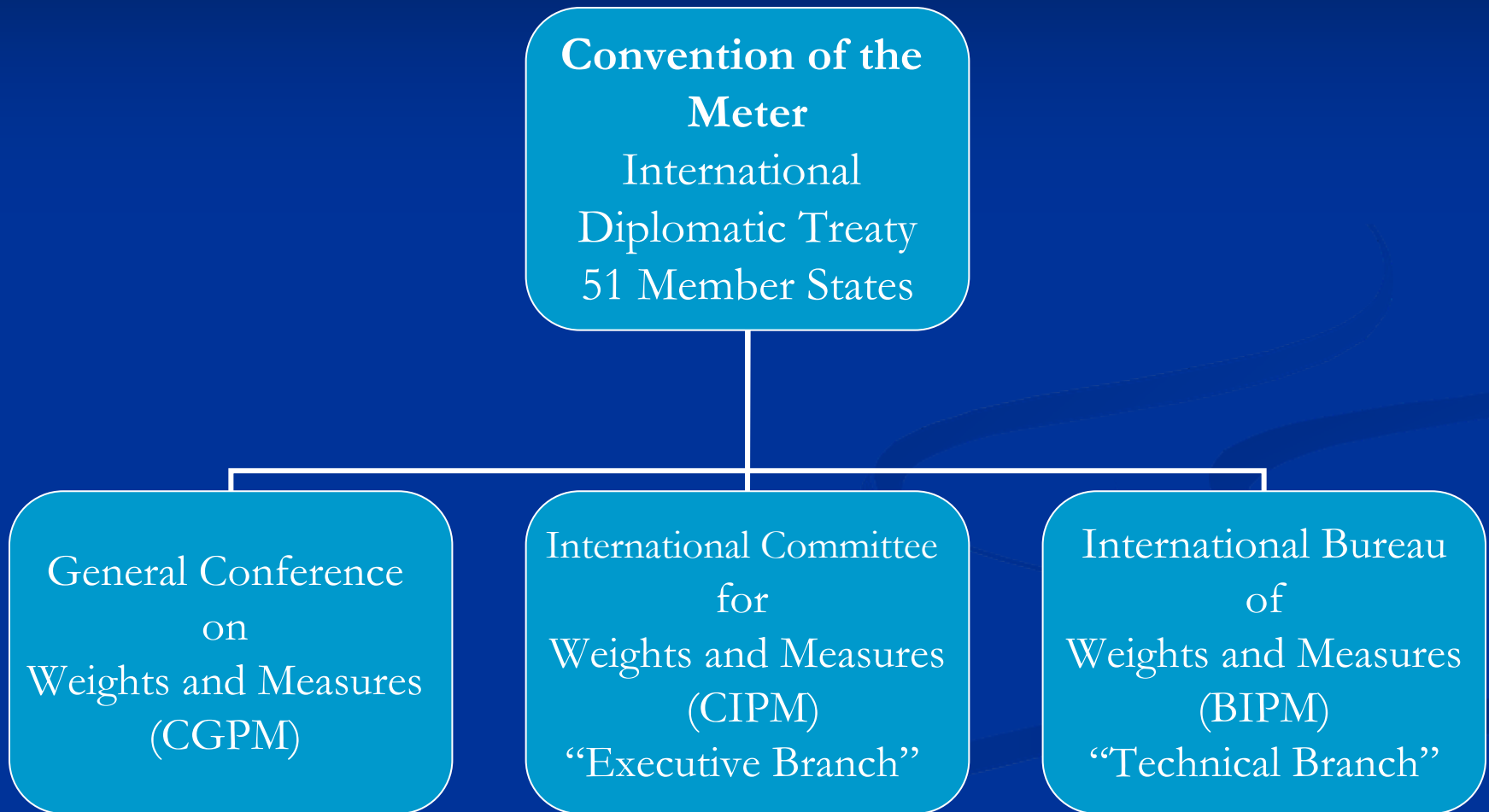
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Outline

- Introduction to the International Traceability Scene
- Key Acronyms and References
- Definition
- Discussion
- Summary

Metrology Authoritative Bodies



Standards Organizations

International
Organization
for
Standardization
ISO

American National
Standards Institute
ANSI

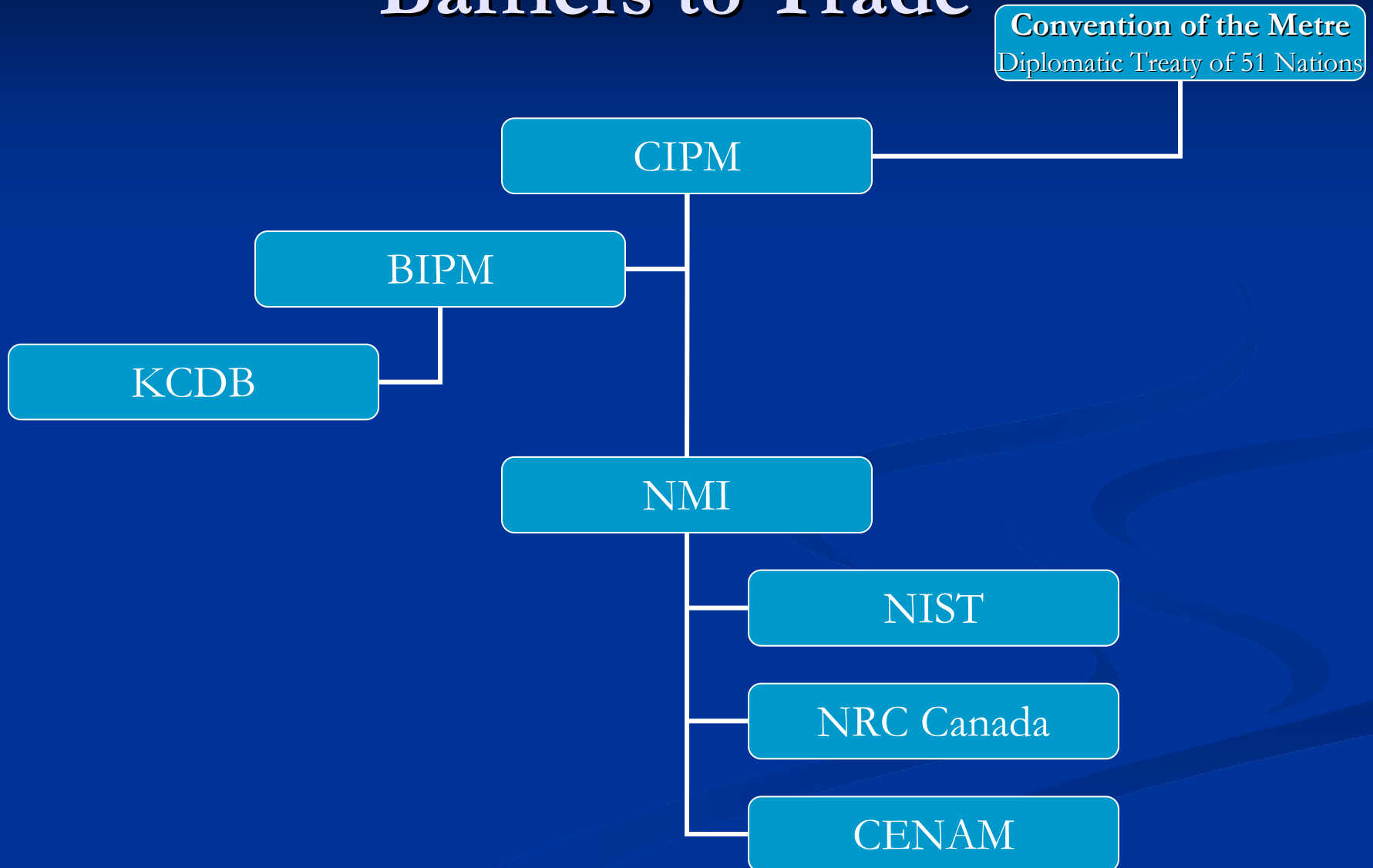
Standards Council of
Canada
SCC

Dirección General de
Normas
DGN
Mexico

CIPM Mutual Recognition Arrangement (MRA)

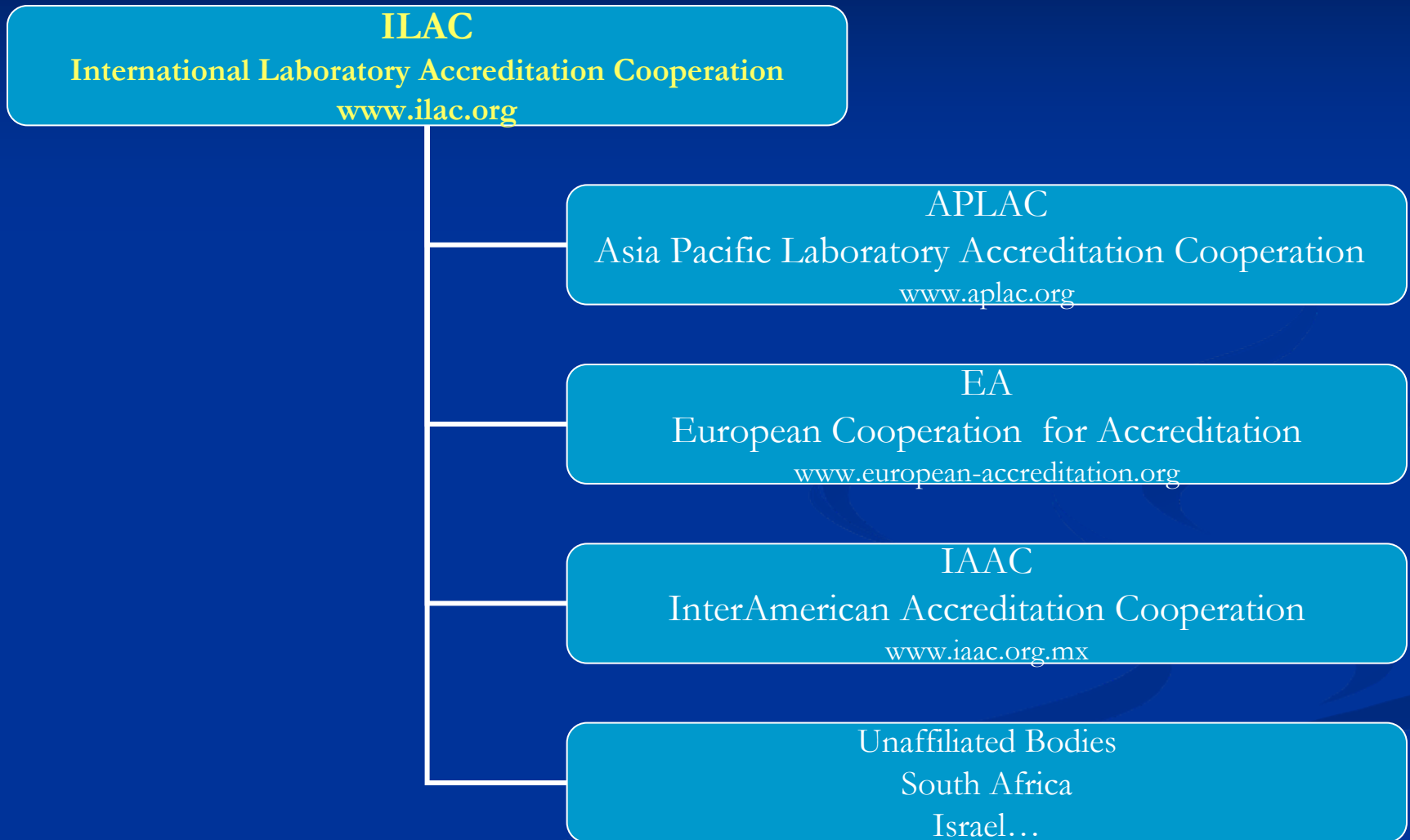
- Global Coordination
- National Metrology Institutes (NMIs) establish degrees of equivalence
 - Calibration Measurement Capabilities (CMC)
 - Uncertainty
- Key Comparisons for base units of the SI
 - KCDB: Key Comparison Data Base

CIPM MRA: To Reduce Technical Barriers to Trade

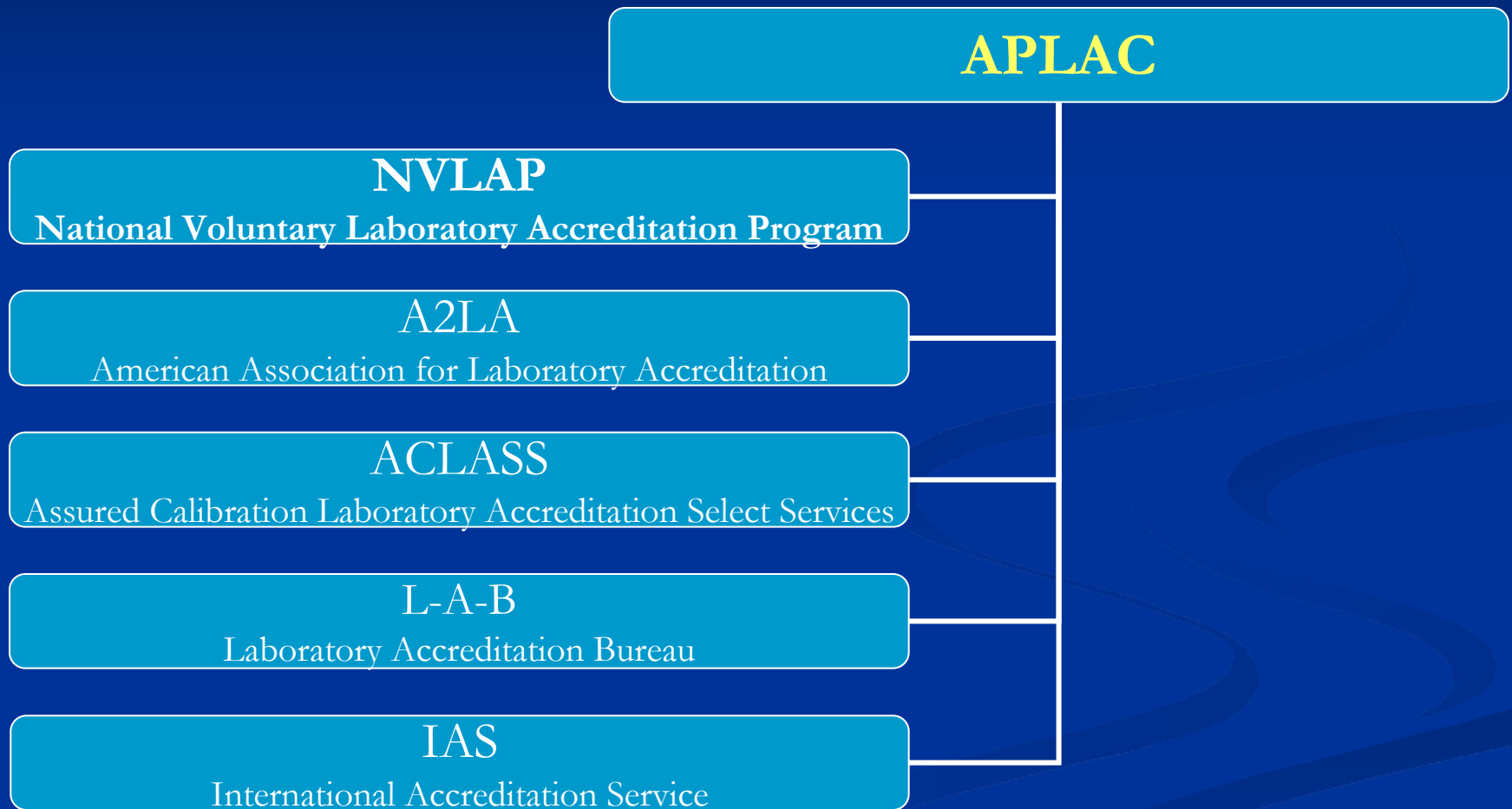


Accreditation Entities

Mutual Recognition Arrangements (MRAs)



MRA Signatory Accrediting Bodies in the United States



Important Acronyms

- SI – International System of Units
- VIM – International Vocabulary of Metrology
- ITS-90 - International Temperature Scale realized in 1990
- CRM – Certified Reference Material
- SRM[®] - Standard Reference Material (Registered trademark from NIST)
- CMC – Calibration Measurement Capability
- M & TE – Measurement and Test Equipment

SI Base Units

Base Quantity	Name	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Thermodynamic Temperature	kelvin	K
Amount of Substance	mole	mol
Luminous Intensity	candela	cd

Derived SI Units

- Ratio (dB)
- Field Strength (dBuV/m)
- Resistance and Impedance (ohm)
- Conductivity

Important References

- ISO/IEC Guide 99:2007 *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*
- ISO/IEC 17025:2005 Clause 5.6 *Measurement Traceability*
- ILAC-P10:2002 *ILAC Policy on Traceability of Measurement Results*
- NIST Handbook 150:2006 *Annex B: Implementation of traceability policy in accredited laboratories*

International Vocabulary of Basic and General Terms in Metrology (VIM 2: 1993)

Traceability:

- "...the property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons all having stated uncertainties."

ISO/IEC Guide 99:2007

VIM 3:2007

- 2.41 METROLOGICAL Traceability
 - “property of a **measurement result** whereby the result can be related to a reference through a documented unbroken chain of **calibrations**, each contributing to the **measurement uncertainty**”

Metrological Traceability

- Reference: definition of a measurement unit through its practical realization
 - Experimentally determine the definition of a unit of measurement. (e.g., ITS-90 Temperature scale)
 - It can then be transferred to practical measurements
- Reference: Measurement standard
 - i.e., Standard Reference Material (SRM[®]) or CRM

Metrological Traceability

- Different than “Traceability” ?
 - Traceability is an abbreviated term
 - CAN mean “metrological traceability
 - CAN mean “sample traceability”
 - CAN mean “document traceability”
 - CAN mean “instrument traceability”
 - CAN mean “material traceability”
- The last four refer to the *physical* history (trace) of the artifact.
- Metrological Traceability refers to the *measurement* history of the “artifact”
- Therefore, the term “Metrological Traceability” is preferred.

Metrological Traceability

- Requires a calibration hierarchy
 - Each step of the process
 - Time each reference used in the hierarchy – HISTORY of the references
- All input quantity values (each component or reference) must be metrologically traceable
 - Commensurate with contribution to the measurement result

Metrological Traceability of the Measurement Result

- Does not ensure the uncertainty is adequate for a given purpose
- Does not ensure there are no mistakes
- So... what does it do?
 - Provides an unbroken chain of measurements
 - Provides a complete “picture” of **all** the contributors to the uncertainty of the measurement result
- Provides linkage mechanism back to the source

Elements Confirming Traceability (to the Source)

- An unbroken metrological traceability chain to an International or National Measurement Standard
- A documented measurement uncertainty
- A documented measurement procedure
- Accredited technical competence
- Metrological traceability to the SI where possible
- Appropriate Calibration Intervals
(ILAC P-10:2002)

ISO/IEC 17025:2005 Clause 5.6

Measurement Traceability

- 5.6.1 “All equipment used for tests and/or calibrations, including equipment for subsidiary measurements (e.g. for environmental conditions) having a significant effect on the accuracy or validity of the result of the test, calibration or sampling SHALL be calibrated before being put into service. The laboratory shall have an established program and procedure for the calibration of its equipment.”

17025:2005 Clause 5.6

- All equipment ... having a significant effect on the accuracy or validity of the result of the test, calibration or sampling
 - Do environmental conditions have an effect?
 - Temperature
 - Humidity
 - What are the pieces of the measurement or testing system?
 - Have they been calibrated prior to use?
 - What's the calibration history or hierarchy?

17025:2005 Clause 5.6

- “The laboratory SHALL have an established program...” which should include:
 - Selecting
 - Using
 - Calibrating
 - Checking
 - Controlling and maintaining

Measurement Standards, Reference Materials
used as measurement standards, M & TE.

ILAC P10:2002 Concept of Traceability of Measurement Results

- Unbroken chain of comparisons to stated references
- Uncertainty of Measurements for each step in the chain
- Documentation for each step in the chain
- Evidence of competence to perform one or more steps in the chain
- Reference to SI units, where possible, ending the chain at the primary standards for the realization of the SI unit
- Evidence of calibrations repeated at appropriate intervals dependent upon uncertainty required, frequency of use, way of use, stability of equipment (Program and Procedure, Clause 5.6 of 17025:2005)

ILAC P10:2002 Policy on Traceability of Measurement Results

- Laboratories shall demonstrate traceability to the International System of Units (SI)
 - Critical equipment, therefore, measurement results generated by the equipment
 - Certified Reference Materials (CRMs)
- Accredited labs shall derive the traceability from
 - Appropriate NMI
 - Signatory to the CIPM MRA and CMCs published on the KCDB at the BIPM
 - Calibration laboratory demonstrating competence, capability and traceability with appropriate measurement uncertainty; e.g. , proficiency testing

ILAC P10:2002 Policy on Traceability of Measurement Results

- Where relevant and possible, accredited testing labs are required to ensure the traceability of their in-house calibration and/or accredited test results to an external calibration provider
 - Accredited
 - Suitably small uncertainties
 - Demonstrated competence
 - NMI
 - National reference laboratory
 - CRM
 - Mutual consent/agreed method

ILAC P10:2002 Policy on Traceability of Measurement Results

- Laboratories holding only management systems certificates (e.g. ISO 9001) have NOT demonstrated the necessary technical competence.
- ISO 9001 \neq metrological traceability compliance

NIST Handbook 150: 2006 Annex B

- Labs must demonstrate proper use of standards and equipment (competency)
- Calibration certificates must include:
 - Uncertainty of measurement and/or
 - Statement of compliance with an identified metrological specification.
 - TUR is a specification not an measurement uncertainty
- Physical standards and M&TE submitted to NIST or another NMI recognized under the CIPM agreement

NIST Handbook 150: 2006 Annex B

- To assure traceability, accredited laboratories may calibrate their own equipment if the requirements of Clause 5.6 are met
 - Testing labs performing calibrations only for themselves do not need to be accredited for that calibration but traceability must be demonstrated (i.e., authorized and trained staff, a cal procedure, uncertainty budget, and traceability)
 - Calibration labs performing calibrations supporting their accredited services need not be accredited for that calibration but traceability must be demonstrated

NIST Handbook 150:2006 Annex B

- Calibrations may also be obtained from:
 - NVLAP-accredited laboratories , or
 - Laboratories accredited by any Accrediting Body with whom NVLAP has a mutual recognition arrangement
 - Signatory status
 - Current signatory status is available through the NVLAP website (Links to ILAC and APLAC homepages)
 - Check frequently as status does change

NIST Handbook 150:2006 Annex B

- What if there is no accreditation by an MRA partner?
 - Document that none is available
 - Audit the claim of traceability
 - Pursue the traceability chain until metrological traceability to appropriate stated references is completely validated
 - Maintain a complete record of the audit and results
 - On-site visit may not be necessary

NIST Handbook 150:2006 Annex B

- Metrologically traceable calibration services not available or appropriate?
 - Demonstrate comparison to a widely used standard
 - Clearly specified
 - Mutually agreeable to all parties

Summary

- Metrological traceability is achievable and able to be demonstrated for testing and calibration laboratories.
- Information contained in the reference documents is mutually supportive
- Information contained in reference documents provides guidance to
 - Help laboratories assess their own metrological traceability
 - Help assessors evaluate the compliance to the requirements of ISO/IEC 17025:2005 with regards to metrological traceability