

NIST Metric Program

US Metric Association Virtual Open House

18 May 2022



National Institute of
Standards and Technology
U.S. Department of Commerce



Elizabeth Benham

Office of Weights and Measures
Metric Program

Mission:

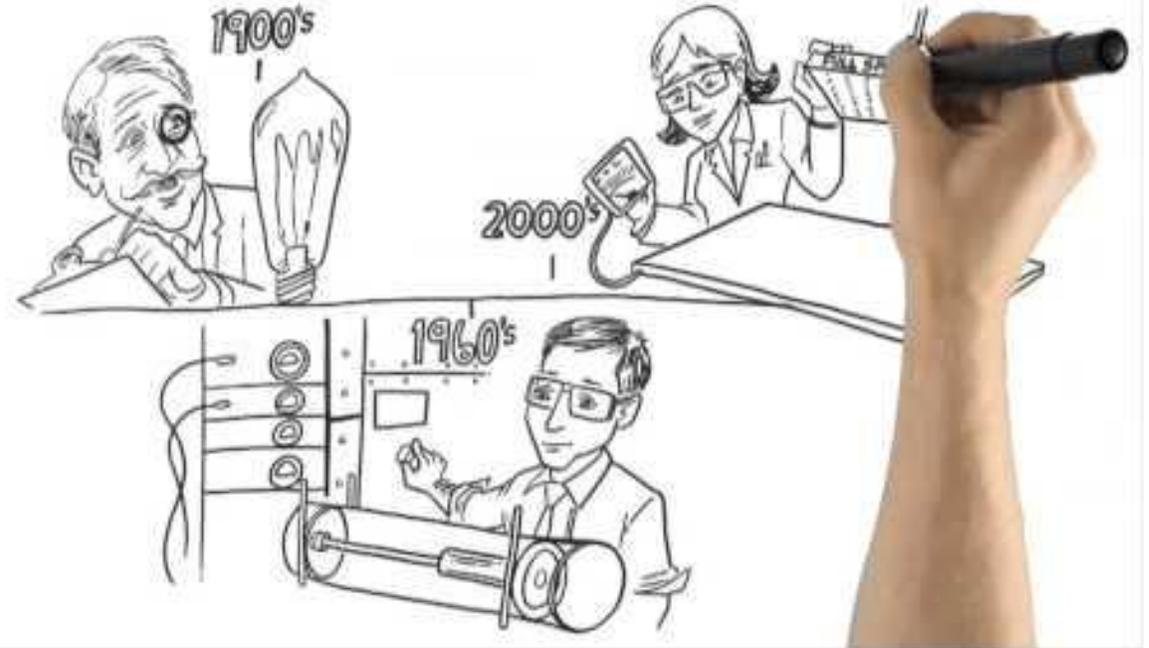
Promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life

Vision:

Be the world's leader in creating critical measurement solutions and promoting equitable standards. Our efforts stimulate innovation, foster industrial competitiveness, and improve the quality of life



Measurements Permeate Every Aspect of Our Lives



Video: NIST Illustrated

Timeline:

- **1901 - National Bureau of Standards**
- **1988 - National Institute of Standards and Technology**



NIST's original campus stood at the intersection of Connecticut Ave. and Van Ness in Washington, D.C.

March 3, 1901

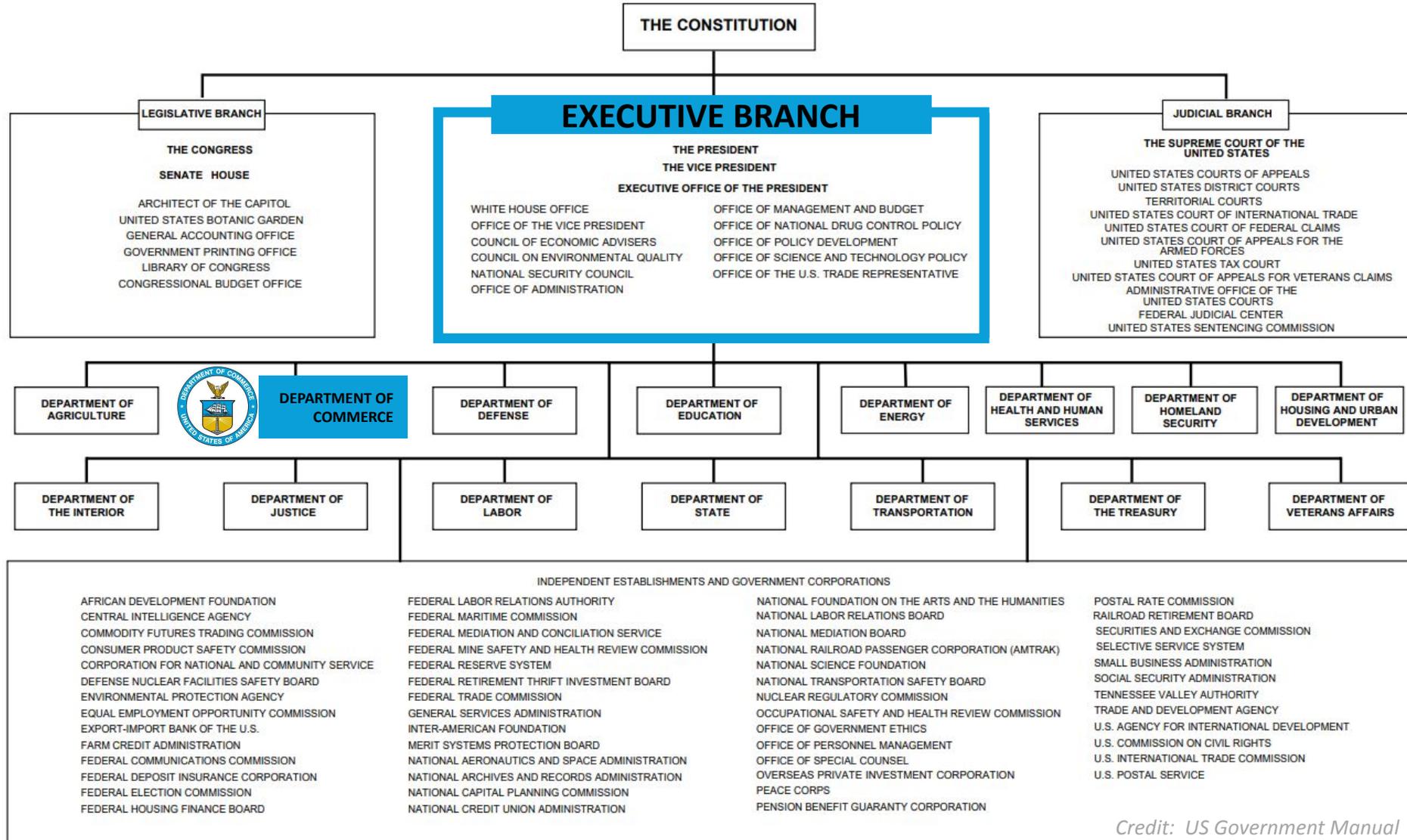
NIST Founded

Heeding the call from the nation's scientists and industrialists to establish an authoritative domestic measurement and standards laboratory, the U.S. Congress founded NIST on March 3, 1901. The fledgling agency quickly assembled standards for electricity, length and mass, temperature, light, and time, and created a system to transfer those values to the public.

➤
First Director:
Samuel W.
Stratton
March 3, 1901



The Government of the United States

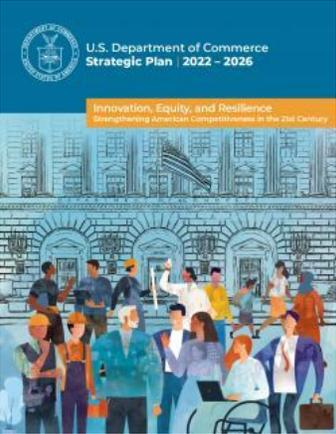
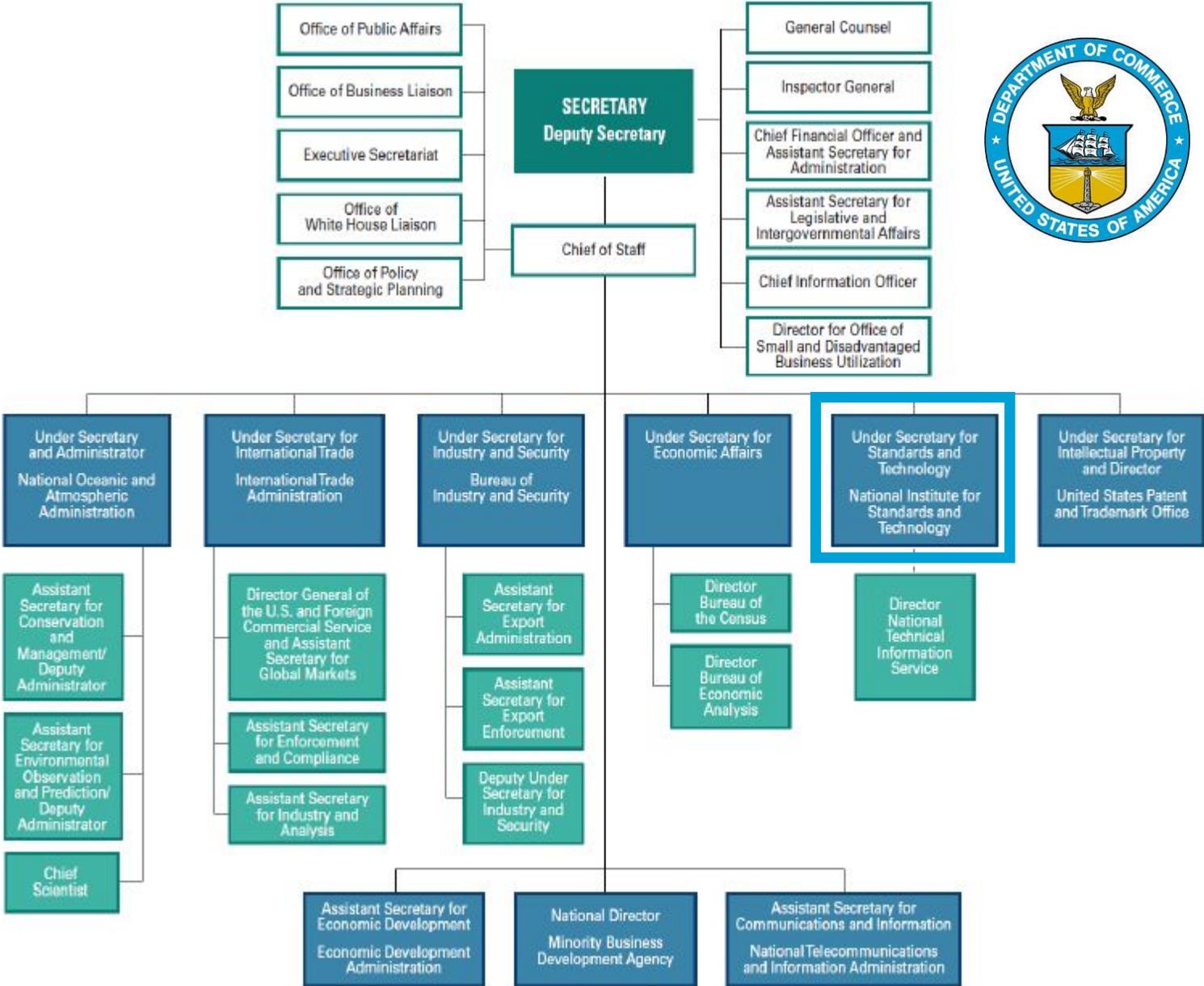


Credit: US Government Manual

Department of Commerce



Gina M. Raimondo
Secretary of Commerce



Credit: Department of Commerce

NIST National Institute of
Standards and Technology
U.S. Department of Commerce

Main Campuses



Gaithersburg, Maryland (234 hectare)



Boulder, Colorado (84 hectare)

Additional Locations:

- **Joint Institute for Laboratory Astrophysics (JILA)** - Boulder, Colorado
- **Hollings Marine Laboratory** - Charleston, South Carolina
- **Institute for Biosciences and Biotechnology (IBBR, formerly CARB)** - Rockville, Maryland
- **Joint Quantum Institute (JQI)** - College Park, Maryland

NIST ORGANIZATION CHART



Laurie E. Locascio, Ph.D.
Under Secretary of Commerce
for Standards and Technology
and NIST Director

- ~ **3400** scientists, engineers, technicians and support and administrative personnel
- **Hosts ~ 3800** associates from academia, industry, other government agencies





PHYSICAL MEASUREMENT LABORATORY

Gauging nature on all scales



Credit: NIST

James G. Kushmerick, Ph.D.
Director, Physical Measurement Laboratory (PML)

- Maintenance, development, and dissemination of U.S. national measurement standards
- Full suite of calibration services
- + 600 employees and + 700 guest researchers at Gaithersburg, MD and Boulder, CO campuses

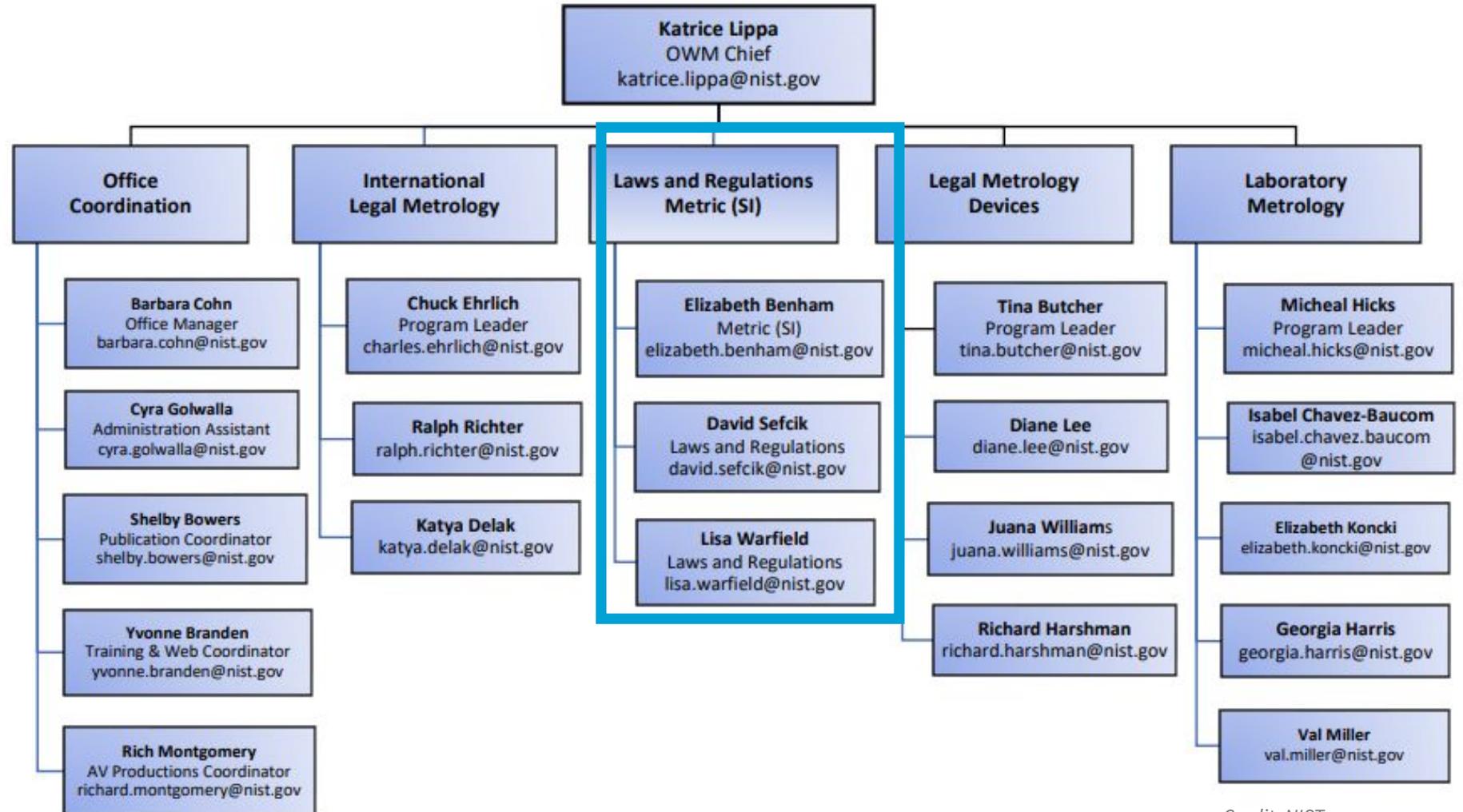
- Applied Physics Division
- Microsystems and Nanotechnology Division
- Nanoscale Device Characterization Division
- **Office of Weights and Measures**
- Quantum Electromagnetics Division
- Quantum Measurement Division
- Quantum Physics Division
- Radiation Physics Division
- Sensor Science Division
- Time and Frequency Division



Office of Weights and Measures

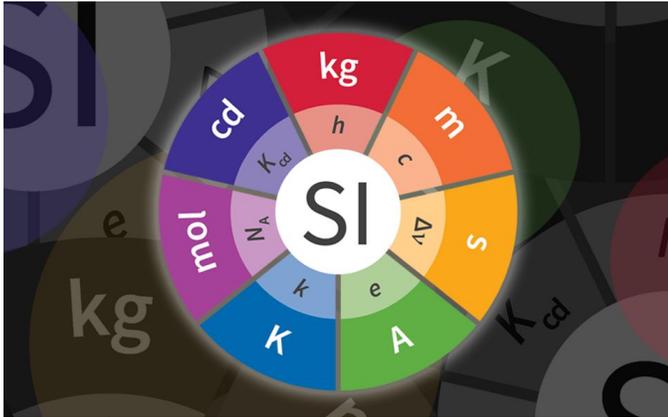


Katrice Lippa, Ph.D.
Director, Office of Weights
and Measures



Office of Weights and Measures

» Over 185 years of service



Core Areas

- ***U.S. and International Standards.*** Develops documentary standards important for legal metrology devices and laboratory metrology in practice
- ***Traceability for the States.*** Facilitates State weights and measures standards traceability to the International System of Units (SI) through NIST. Develops procedures for legal metrology inspections & tests. Provides guidance on uniform weights and measures laws and regulations adopted by State and local weights and measures programs
- ***Technical Guidance and Training.*** Designs & delivers training for State laboratory metrologists, weights and measures officials, legal metrology device practitioners, and metric (SI) educators

Responsibilities

NIST Organic Act - 15 U.S.C. 271 § 2(c) - In carrying out the functions specified in subsection (b), the Secretary, may, among other things -

- (1) construct physical standards;
- (2) test, calibrate, and certify standards and standard measuring apparatus;
- (3) study and improve instruments, measurement methods, and industrial process control and quality assurance techniques;
- (4) cooperate with the States in securing **uniformity in weights and measures laws** and methods of inspection;

Fair Packaging and Labeling Act §1458. Cooperation with State Authorities; Transmittal of Regulations to States;

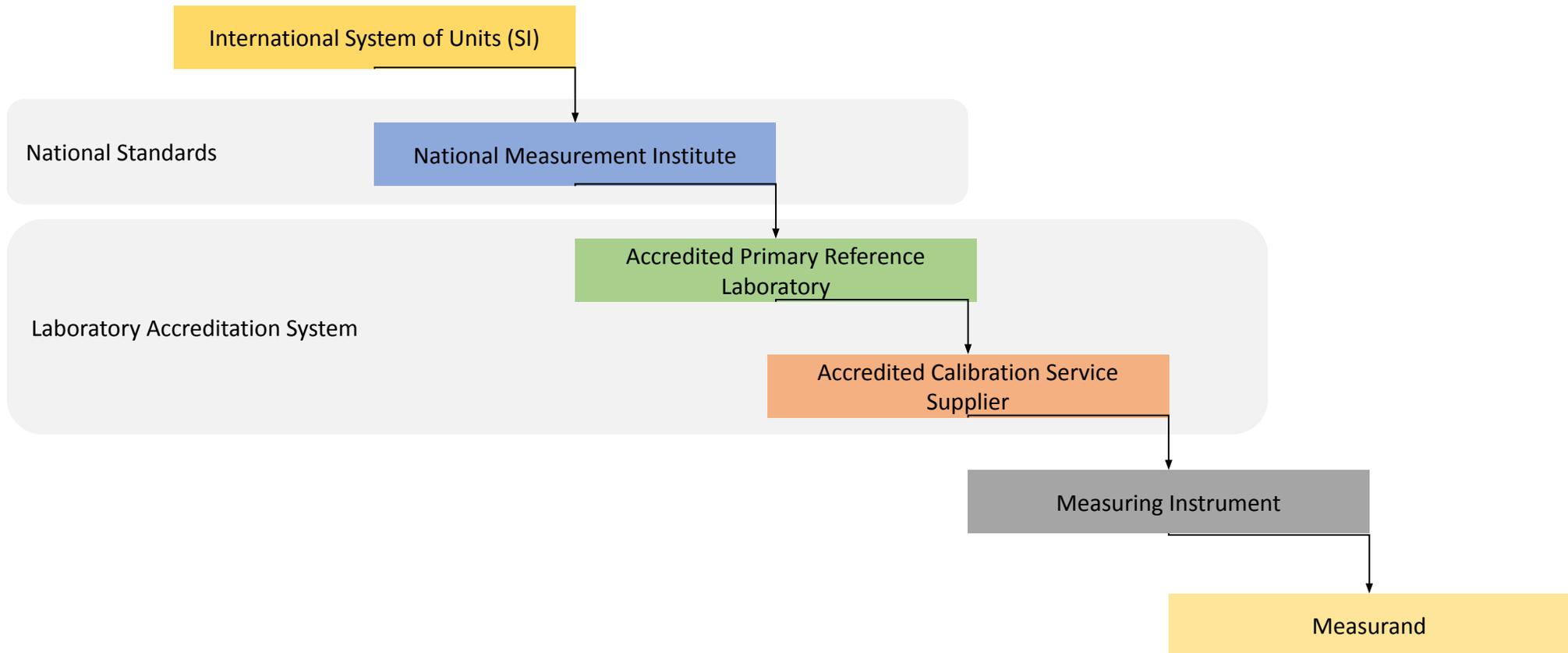
(a) A copy of each regulation promulgated under this chapter shall be transmitted promptly to the Secretary of Commerce, who shall (1) transmit copies thereof to all appropriate State officers and agencies, and (2) furnish to such State officers and agencies information and assistance to **promote to the greatest practicable extent uniformity** in State and Federal regulation of the **labeling of consumer commodities**

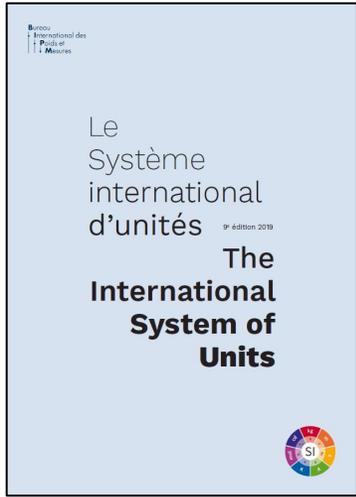




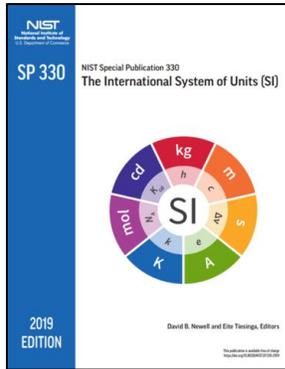
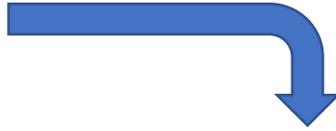
Metrological Traceability

An Unbroken Chain from the SI to the Marketplace

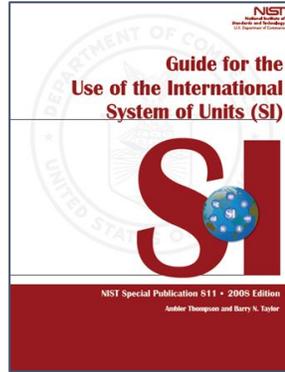




BIPM SI Brochure



NIST SP 330



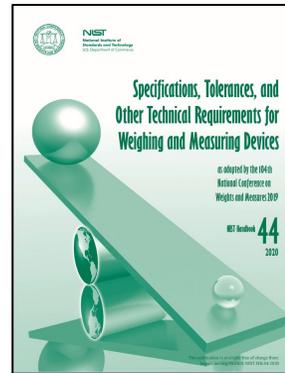
NIST SP 811



Federal Register



IEEE/ASTM SI 10



NIST HB 44

Stay Connected

NIST [View as a Web Page](#)

Office of Weights and Measures (OWM)

Measurement Matters

A circular diagram with 'SI' in the center. The outer ring contains units: kg, m, s, A, K, mol, and cd. The inner ring contains symbols: h, c, Δv, e, k, N_A, and K_B.

Credit: NIST

- **Quarterly digital newsletter**
- **Articles of interest**



Metric Program



Elizabeth Benham

Program Coordinator



Dinelka Jagoda

Montgomery College

Intern



Tanna Ngyuen

Montgomery College

Intern

Travis White Jr.

Mercer University

SURF Intern (Summer 2022)

OWM Staff & Technical Experts Directory

Type of Information	Contact	Phone	Email
Weights & Measures			
Katrice Lipa, Chief		(301) 975-3116	katrice.lippa@nist.gov ✉
Administrative Staff:			
Office Manager and General Inquiries	Barbara Cohn	(301) 975-4004	barbara.cohn@nist.gov ✉
Publication Coordinator	Shelby Bowers		shelby.bowers@nist.gov ✉
Training Coordinator, OWM Webmaster, and OWM Contacts System Administrator	Yvonne	(301) 975-	yvonne.branden@nist.gov ✉
Metric Program			
AV Productions Coordinator			
Metric System (SI) Information Federal Agency Metric Progress Reports Unit Conversion U.S. Metrication	Elizabeth Benham	(301) 975-3690	elizabeth.benham@nist.gov ✉



Metric Program

Increase Use of the SI:

Trade and Commerce

Everyday Life



Legal Directives:

1866 - Metric Law

1975 - U.S. Metric Conversion Law

1991 - Presidential Executive Order 12770

Policy Highlights

Preferred System of Measurement for
Trade & Commerce

Convert on a Voluntary Basis



Seek ways to Increase Understanding

- Educational Information
- Guidance
- Government Publications

Responsibilities

U.S. Metric Conversion Law of 1975 (15 U.S.C. 205a et seq.)

As amended by the Omnibus Trade and Competitiveness Act of 1988

- Seek out ways to increase metric system understanding through educational information and guidance and in Government publications
- SP 330 and SP 811 - Official interpretation of SI for the U.S.

Presidential Executive Order 12770 of July 25, 1991 (FR 56 35801-35803)

- Guidance and Coordination
- Agency Progress Reports and Guidelines



METRIC PROGRESS REPORT GUIDELINES FY2021 (2020 TO 2021)

BACKGROUND

The Presidential Executive Order 12770 and the Metric Conversion Act designates the International System of Units (SI), commonly known as the metric system of measurement, as the preferred system of weights and measures for use in trade and commerce, and requires the use of the SI system, to the extent economically feasible, by each federal agency and department in its procurements, grants, and other business-related activities. Metric usage is not required if its use is impractical or is likely to cause significant inefficiencies or loss of markets to United States firms.

Federal agencies and departments are required to formulate transition plans and to communicate them to the Metric Program at the National Institute of Standards and Technology (NIST).

Heads of departments and agencies must establish an effective process for a policy and program level review of proposed exceptions to metric usage, as well as to take initiatives to increase use of SI in industry, and seek out ways to increase understanding of the metric system of measurement through educational information and guidance and in government publications.



**PLEASE SEND
ANNUAL AGENCY
REPORT TO:**

TheSI@nist.gov
Or
NIST Office of
Weights and Measures
Metric Program
100 Bureau Dr, MS2600
Gaithersburg, MD
20899-2600

BY: May 1, 2022

NIST
National Institute of
Standards and Technology
U.S. Department of Commerce
NIST.GOV/METRIC

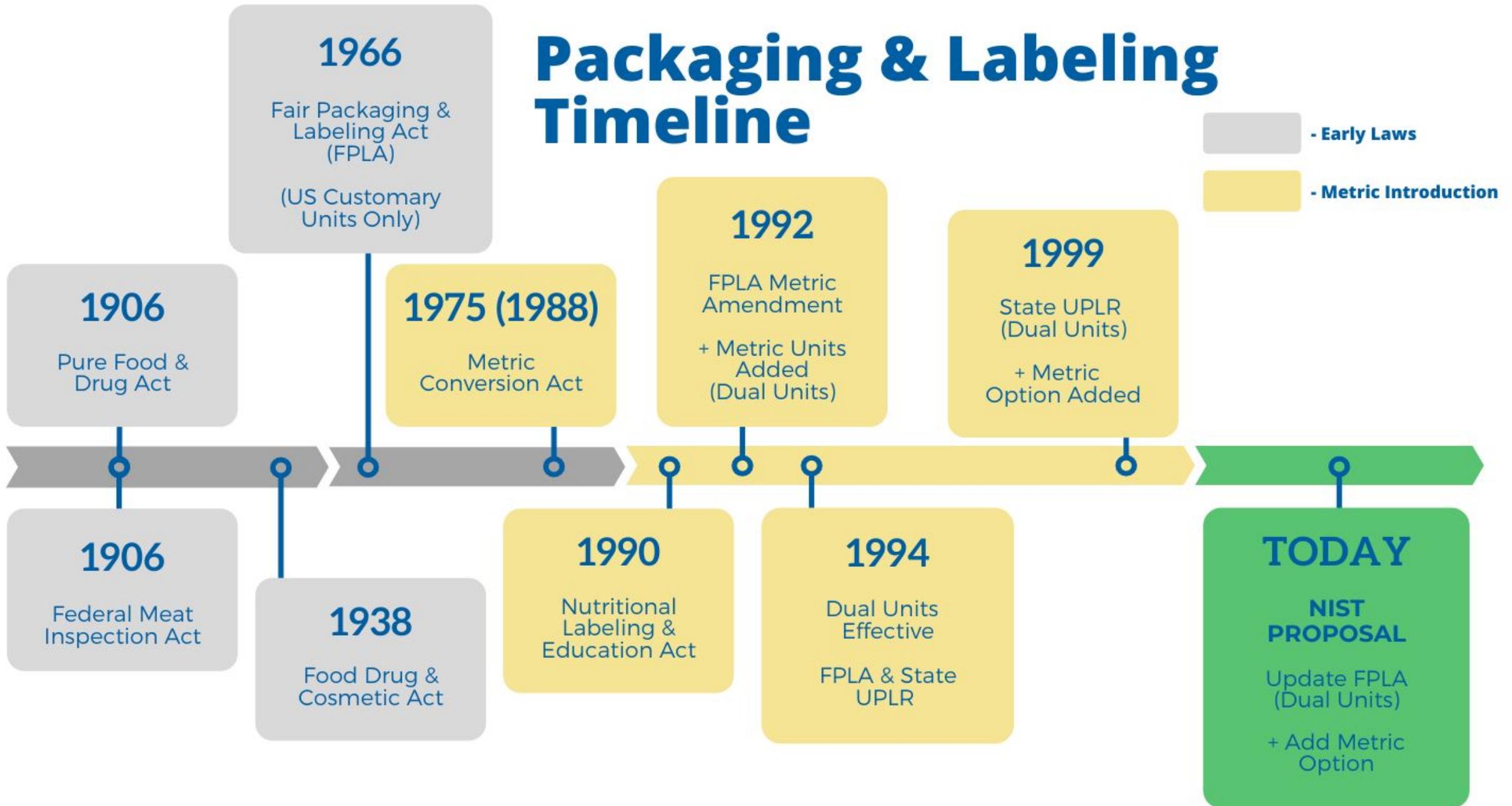
Metric Program Assistance



NIST
National Institute of
Standards and Technology
U.S. Department of Commerce

- Coordinate, Collaborate, Provide Technical Guidance
- Industry, Trade Associations, State & Federal Agencies, Consumers
 - Sector by Sector Basis
 - Online Training
- Consumer & User Education Materials
- Technical Resources

Packaging & Labeling Timeline



Proposal to Amend the Fair Packaging and Labeling Act (FPLA)



Credit: Pixabay

EXPAND LABELING OPTIONS TO
BENEFIT U.S. EXPORTS

A Proposal to Amend the Federal Fair Packaging and Labeling Act (FPLA)¹

The diagram shows three product packaging options. The first is a green box labeled '710 mL' and '24 fl oz (1 Pint 8 oz)'. The second is a red box labeled '710 mL (1.0 Pint)'. The third is a green box labeled '710 mL'. A black plus sign is between the red and green boxes. Below the boxes are two colored bars: a yellow bar labeled 'Dual: Customary + Metric' and a green bar labeled 'Metric'.

NIST OFFICE OF WEIGHTS & MEASURES

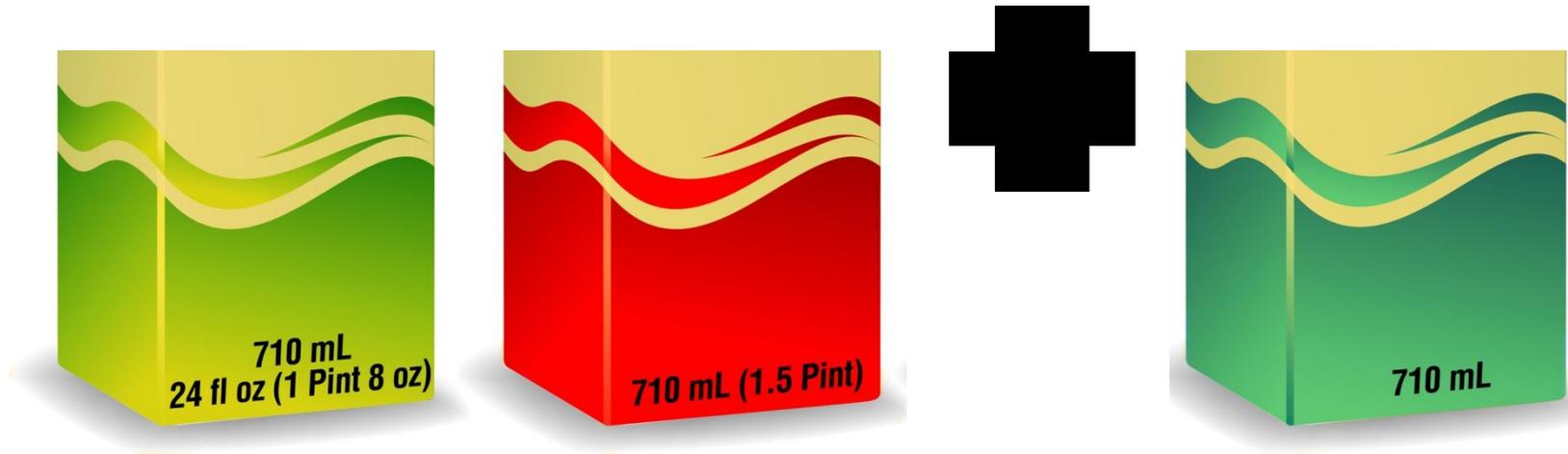
JUNE 1, 2018

Credit: NIST



- Frequently Asked Questions (FAQ) format
- Explores current challenges and opportunities related to FPLA amendment
- Federal law prohibits the majority of U.S. consumer product manufacturers from using export-friendly Metric labeling option
- Ability to respond to marketplace demands and consumer preferences is limited by law
- Proposed text

Comparing Units: Volume



Customary + Metric

Dry Volume

- dry pint
- dry quart
- peck
- bushel

* cord for firewood

Fluid Volume

- ounce
- pint
- quart
- gallon

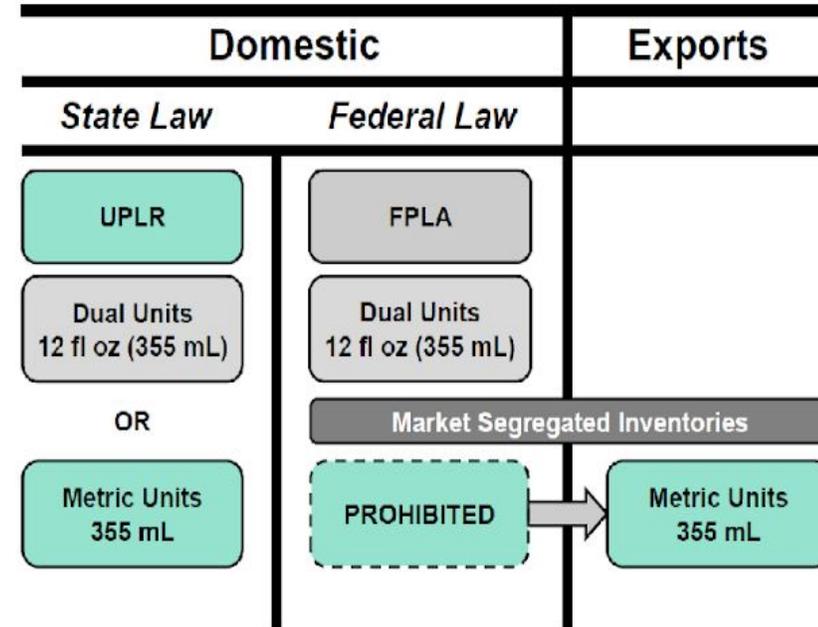
Metric

- milliliter (mL)
- liter (L)
- cubic meter (m³)

Proposal to Amend the Fair Packaging and Labeling Act (FPLA)



Amendment expands U.S. Manufacturer options and gains alignment with State labeling laws



GOAL: Facilitate U.S. (esp. small) business to EXPAND exports

Proposed Metric option would eliminate the need to maintain segregated product inventories

Consumer Value Comparison....

Determine the Best Value

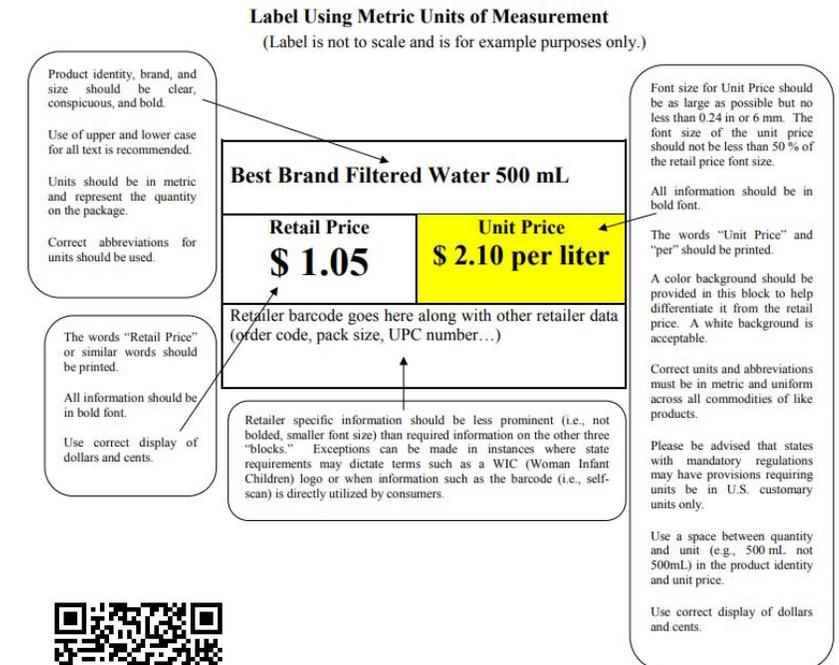
Brand A	Brand B	Brand C
		
225 mL (7.6 fl oz)	300 mL	475 mL (16 fl oz)
Price: \$ 3.19	Price: \$ 3.39	Price: \$ 5.79
Unit Price: \$ 1.42 per 100 mL	Unit Price: \$ 1.13 per 100 mL	Unit Price: \$ 1.22 per 100 mL

- Customers use unit pricing on store shelves and online e-commerce platforms to make value determinations
- In this example, Brand B is the best value

Adopt Unit Pricing

Brick + Mortar, E-commerce

NIST Special Publication (SP) 1181
Unit Pricing Guide (2015)



Credit: NIST

Metric Unit Pricing

eCommerce



IGP BALSAMIC
Vinegar of Modena

QUALITY	WELL BALANCED, SLIGHTLY SWEET
ORIGIN	ITALY, MODENA
USAGE	USE IN MARINADES, ON SALADS, MEAT DISHES

\$5.00
per 100 ml

Dr. Pepper

Dr Pepper Soda Pop, 2 L bottle

\$1.98 99.0 ¢/l

★★★★☆ (4.7) 612 reviews

2 LITERS

\$1.98 Add to cart

Minute Maid

Minute Maid Zero Sugar Lemonade
Bottle, 52 fl oz

\$2.38 \$1.56/lt

★★★★☆ (4.0) 73 reviews

52oz

\$2.38 Add to cart

NIST Education Webpage





NEST-R Resource Registry

[Learn More](#)



Metric Program

[Learn More](#)



Experiential Learning Opportunities

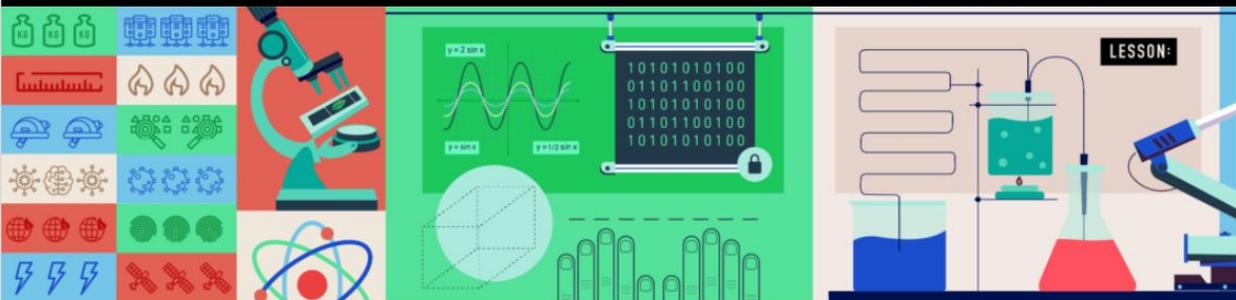
[Learn More](#)



K-12 Curriculum Materials

[Learn More](#)

NIST Educational STEM Resource Registry (NEST-R)



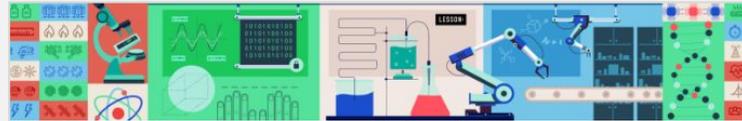
Welcome to NEST-R!

A catalog of STEM educational resources from the National Institute of Standards and Technology

NEST-R has something for everyone! From K-12 to Postgraduate Students, Parents, Teachers, or Working Professionals, we invite you to explore the catalog of resources to deepen your knowledge or discover new subjects!

[Click here to explore the NEST-R catalog!](#)

NEST-R Homepage



Welcome to NEST-R!

A catalog of STEM educational resources from the National Institute of Standards and Technology

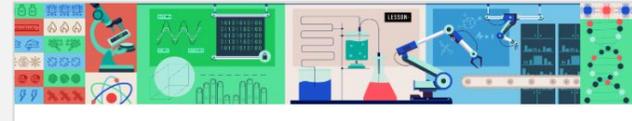
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Resource Types

- Education**
Click here to discover STEM Education resources.
- Workforce Development**
Click here to discover STEM Workforce Development resources.
- Events**
Click here to discover STEM Events.

Search Page



metric [Search](#)

From NESTR 157

Sort | Share Query | Share PIDs | [Done](#)

Type: (Clear)

- Education Resources
- Event (42)
- Workforce Development
- Collection (1)
- Community (1)
- Dataset (0)

Topic: (Clear)

Energy to Spare: NIST Completes Successful Net-zero Energy House Experiment

Subject keywords: buildings and construction, indoor air quality, climate, energy, alternative energy, energy efficiency

[Visit resource directly](#)

A Record

[Share PID](#) [Back to previous](#)

SI Education & Training

[Cite this resource!](#)

[Click here to view this resource \(on external site\)](#)

Permanent link to this record (on this site)

Description: This is the SI Education & Training website provides a curated set of resources to help learners become familiar with SI units, develop measurement quantity reference points, and learn more about SI basics! Educators are encouraged to explore and download materials to support their STEAM curriculum.



Teaching tips:

- 0 to 5 minutes teaching time
- Exploring measurement topics is a fun way for students to connect STEM to everyday life. Describe why SI measurement system familiarity and fluency must be developed along the Science, Technology, Engineering, Arts, and Mathematics (STEAM) career pipeline to produce an U.S. engineering workforce with this essential 21st century skill
- Familiarize learners with SI units
- Develop measurement quantity reference points
- Learn how to use common SI prefixes and the relationship with place value.

Resource types:

- Educational Resource
- Other Multimedia
- Event
- Workforce Development
- Professional Development

Resource formats:

- Text
- Webpage

School subjects:

- STEM: Other
- Other: Social Sciences
- Other: Life Skills

Keywords:

- OWM
- Weight
- Measure
- consumer
- unit
- regulatory
- industry

A Resource

SI Education & Training

f in 



Education

The International System of Units (SI), commonly known as the metric system, is the international standard for measurement. SI use in product design, manufacturing, marketing, and labeling is essential for United States industry's success in the global marketplace. SI measurement system familiarity and fluency must be developed along the Science, Technology, Engineering, Arts, and Mathematics (STEAM) career pipeline to produce an U.S. engineering workforce with this essential 21st century skill.

Become familiar with SI units, develop measurement quantity reference points, and learn more about SI basics! Teachers are encouraged to explore and use these materials to support their STEAM curriculum and classroom measurement science.

Credit: NIST

[Share PID](#)
[← Back to previous](#)

SI Education & Training

Cite this resource! ↗

[Click here to view this resource \(on external site\)](#) ↗

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- Familiarize learners with SI units

- Develop measurement quantity reference points

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Resource formats:

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- STEM:
- Other:
- Social Sciences

- Other: Life Skills

Keywords:

- OWM

- Weight

- Measure

- consumer

- unit

- regulatory

- industry

Example Record

- Descriptions
- Related school subjects
- Target audiences
- Teaching tips
- Estimated teaching time

ROAD TO THE REVISED SI



1799

Metric system is officially adopted in France.

Treaty of the Meter signed by 17 nations.

1875

1889

The International Prototype Kilogram is built.

The International System of Units — the SI — is established.

1960

1967

The second is redefined in terms of the oscillation.

The meter is redefined in terms of the speed of light.

1983

2011

Proposal to define SI fully in terms of seven natural constants.

Updated values of constants published.

2017

NOV. 2018

Group of 10 nations votes unanimously to revise the SI.

Rollout of the revised SI.

MAY 2019



Online Resources SI Redefinition



SI REDEFINITION

Meet the Constants

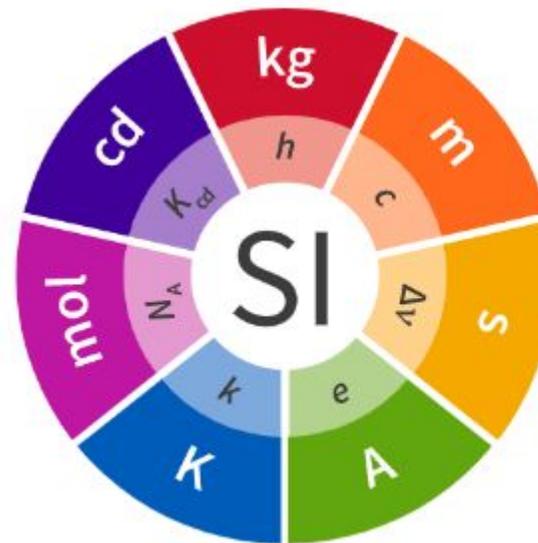
The revised SI rests on a foundation of seven values, known as the constants. (SI is the acronym for the International System of Units, which is informally known as the metric system.) The values of the constants are the same everywhere in the universe. In the revised SI, these constants completely define the seven base SI units, from the second to the candela.

The below graphic shows the seven base SI units and the constants used to define them. **Click on each of the SI units (outer boxes) to see which constants (inner boxes) define them.**

Introduction: Redefining the World's Measurement System

Road to the Revised SI

- Meter
- Kilogram
- Second
- Ampere
- Kelvin
- Mole
- Candela
- Definitions of SI Base Units
- Meet the Constants
- Resources for Reporters
- Credits

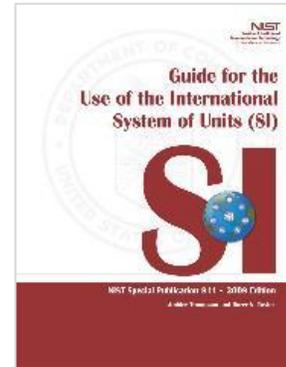


SI Technical Guidance

Reporting Measurement Results

NIST SP 330

NIST SP 811



Manuscript Review Checklist

Guide for the Use of the International System of Units (SI)

Check List for Reviewing Manuscripts

The following check list is intended to help NIST authors review the conformity of their manuscripts with proper SI usage and the basic principles concerning quantities and units. (The chapter or section numbers in parentheses indicate where additional information may be found.)

- (1) Only SI units and those units recognized for use with the SI are used to express the values of quantities. Equivalent values in other units are given in parentheses following values in acceptable units *only* when deemed necessary for the intended audience. (See Chapter 2.)
- (2) Abbreviations such as sec (for either s or second), cc (for either cm³ or cubic centimeter), or mps (for either m/s or meter per second), are avoided and only standard unit symbols, SI prefix symbols, unit names, and SI prefix names are used. (See Sec. 6.1.8.)

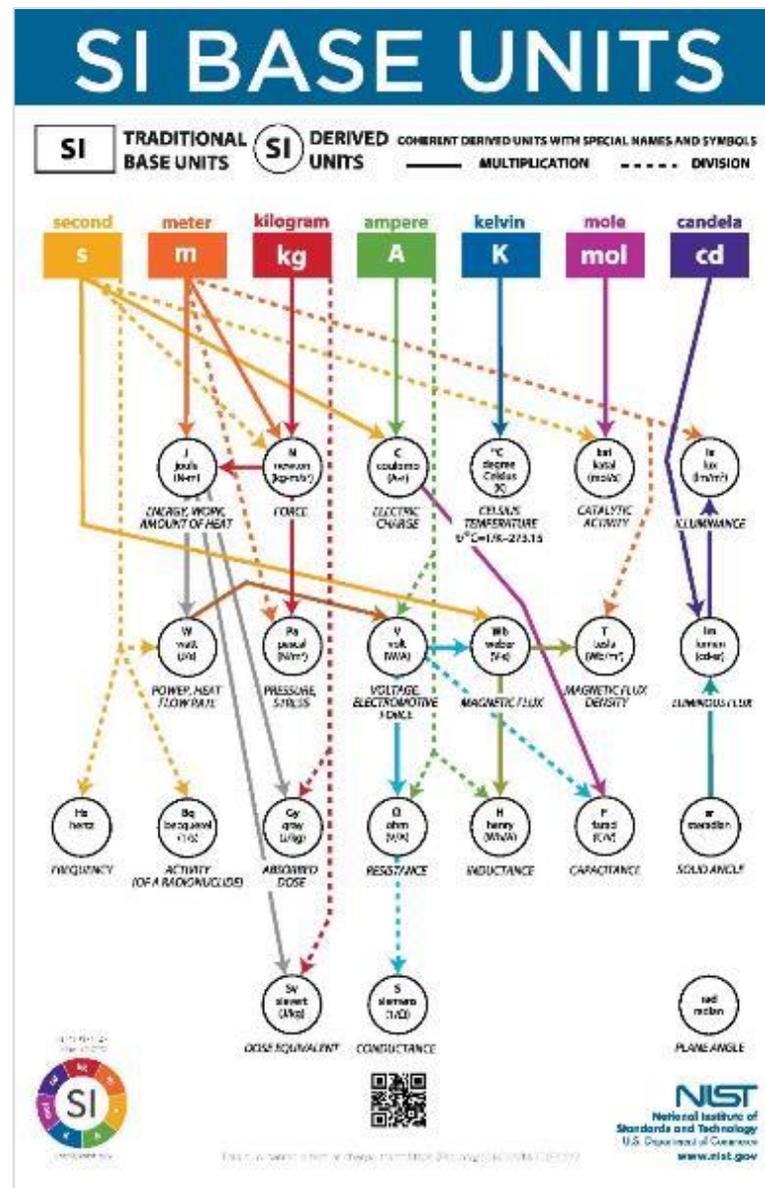
AVOID common
written unit
symbol errors



Publications



NIST SP 1247



Credit: NIST

THE SI MEASUREMENT SYSTEM

The International System of Units (SI) is made up of 7 base units, based on this unit we find Measurement League counterparts. The SI, commonly known as the metric system, is easy to use.

CANDELA (SI UNIT OF LUMINOUS INTENSITY)
The candela is the SI unit of luminous intensity, a derived unit of light power in terms of wavelength and frequency.

KILOGRAM (SI UNIT OF MASS)
The kilogram is the SI unit of mass. It is the only base unit that is not defined in terms of a physical object.

AMPERE (SI UNIT OF ELECTRIC CURRENT)
The ampere is the SI unit of electric current. It is the only base unit that is not defined in terms of a physical object.

MOLE (SI UNIT OF AMOUNT OF SUBSTANCE)
The mole is the SI unit of amount of substance. It is the only base unit that is not defined in terms of a physical object.

KELVIN (SI UNIT OF THERModynamic TEMPERATURE)
The kelvin is the SI unit of thermodynamic temperature. It is the only base unit that is not defined in terms of a physical object.

METER (SI UNIT OF LENGTH)
The meter is the SI unit of length. It is the only base unit that is not defined in terms of a physical object.

NEWTON (SI UNIT OF FORCE)
The newton is the SI unit of force. It is a derived unit, defined in terms of the base units of mass, length, and time.

CANDELA (SI UNIT OF LUMINOUS INTENSITY)
The candela is the SI unit of luminous intensity, a derived unit of light power in terms of wavelength and frequency.

MOLE (SI UNIT OF AMOUNT OF SUBSTANCE)
The mole is the SI unit of amount of substance. It is the only base unit that is not defined in terms of a physical object.

KELVIN (SI UNIT OF THERModynamic TEMPERATURE)
The kelvin is the SI unit of thermodynamic temperature. It is the only base unit that is not defined in terms of a physical object.



SI Measurement System Poster

The Measurement League: Guardians of the SI (Videos)
Superheroes: Mole, Professor Second, Monsieur Kilogram, Mizz Ampere, Dr. Kelvin, Meter Man, & Candela



Credit: J. Wang and B. Hayes/NIST

www.nist.gov/education



Free SI Teacher Kit (U.S. Only)

[Laboratory Homepage](#)[Division Homepage](#)[About OWM](#)[Programs](#)[Resources](#)[Publications](#)

SI Teacher Kits Available for Educators

Attention Teachers! Did you know that you can obtain a free set of metric education resources for use in your classroom? Contact the NIST Metric Program at TheSI@nist.gov and include your name, school, subject, grade level, phone number, and mailing address. The NIST SI Teacher Kit contains a SI Education USB and other measurement resources.

[NIST LC 1140 - Metric Pyramid](#) is a helpful study aid that can be easily constructed with yellow cardstock to keep common approximate unit conversion factors for mass, length, area, volume, temperature, and energy close at hand. It's a great homework helper!

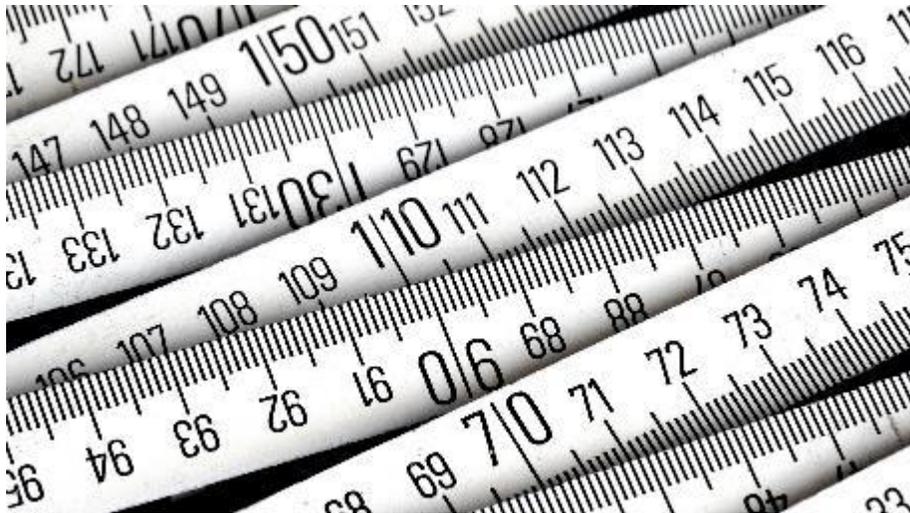


TheSI@nist.gov

SI Education **BEST** Practices



- 1) Teach the SI as a system
- 2) Application - Use metric tools
- 3) Practice - Build proficiency & confidence making measurements
- 4) Develop reference points
- 5) Build estimation skills



- 6) Employ an *Interdisciplinary* approach
- 7) Teach SI all year
- 8) WIIFM - Real life connections & connect to STEAM careers
- 9) Make it fun!
- 10) Don't teach non-SI unit conversions unless *necessary*

Training and Professional Development



OWM Calendar of Events

Webinars:

- Metric System Estimation
- Metric Education Resources
- Virtual Volume Activity (Coming Soon)
- Measurement System Basics for Regulatory Officials



Professional Development

NIST Summer Institute for Middle School Science Teachers

(July)

NIST Search NIST Menu

INTERNATIONAL AND ACADEMIC AFFAIRS OFFICE

NIST Summer Institute

- About Us
- How to Apply
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Use Our Model to Translate Research into the Classroom

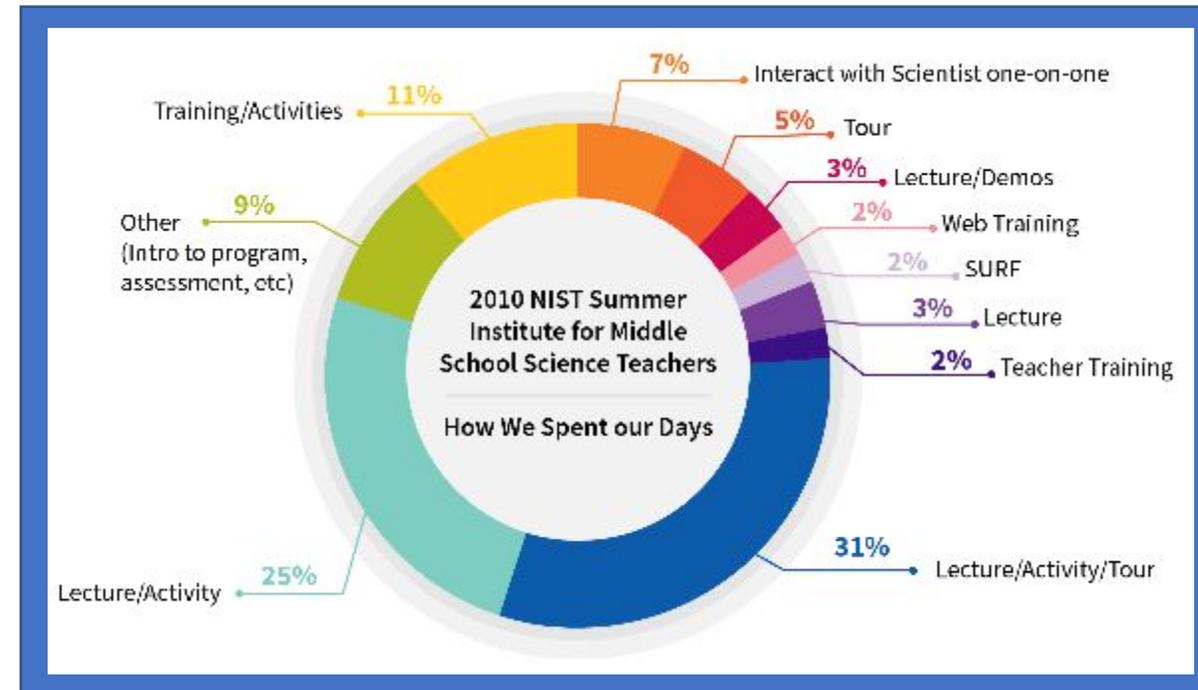
The paper below describes how we at NIST created this program to encourage interest in science in our local middle school community. If you're a teacher, we encourage you to reach out to local laboratories for resources. If you're a scientist, we encourage you to build something similar at your laboratory, and reach out to the schools around you.

[The NIST Summer Institute for Middle School Science Teachers: Translating NIST Research into Activities for the Middle School Classroom](#); by Mary Satterfield, NIST and Susan Heller-Zeisler, NIST

NIST selected middle schools as an area of interest because we noticed that many middle school teachers are asked to teach science topics in ever-changing and expanding fields. Our program introduces teachable ideas in line with school curricula, with lessons that can be immediately implemented.

Benefits from this program include:

- engaging scientists who have a genuine interest in sharing their knowledge with middle school teachers;
- increasing teachers enthusiasm for and confidence in the latest science findings;
- building pre-teen student interest in and excitement about math and science, laying the groundwork for the development of the skilled workforce of the future.



Credit: NIST





NCWM

Weights & Measures Week

Commenced by President
John Adams signing 1st U.S.
weights & measures law
2 March 1799



9 to 15 October 2022



World Metrology Day

Celebrates the Meter Convention
20 May 1875





NIST
National Institute of
Standards and Technology
U.S. Department of Commerce

Collaboration



2008 - NIST, Gaithersburg, MD. David Sefcik (NIST), Lorelle Young (USMA), James Frysinger (USMA), Lisa Warfield (NIST), Kenneth Butcher (NIST), & Elizabeth Benham (NIST)



2008 - USMA HQ, Northridge, CA. Valarie Antoine (USMA), Elizabeth Benham (USMA) & Lorelle Young (USMA)



2019 - NIST, Gaithersburg, MD. Don Jordan (USMA), Don Hillger (USMA), Elizabeth Benham (NIST), Mark Henschel (USMA), Doug Olson (NIST), & Paul Trusten (USMA)

Metric Program

NIST

For More Information

Elizabeth Benham

301-975-3690

elizabeth.benham@nist.gov

NIST Office of Weights and Measures

100 Bureau Drive MS 2600

Gaithersburg, MD 20899-2600

www.nist.gov/metric

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TheSI@nist.gov

Metric Program Training



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