

# Building Quality and Confidence in Carbon Measurement Systems

ORAP Panel  
Dec 3, 2024

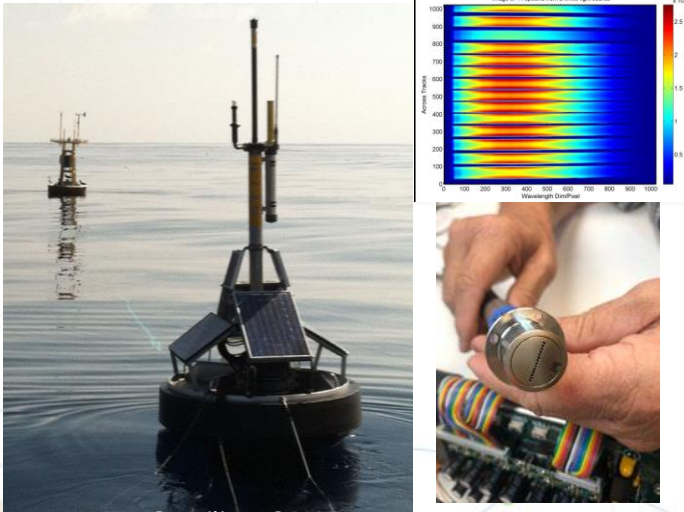
Pam Chu  
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# NIST, Department of Commerce

Promotes U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology to enhance economic security and improve our quality of life.

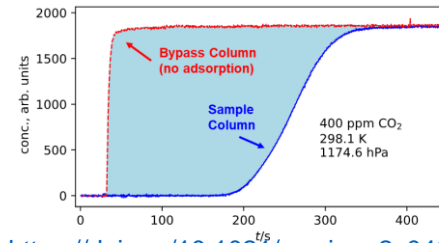
## Measurement Technologies



Develop critical measurement science to accelerate innovation, scalability, & **reduce uncertainties**

## Benchmark Measurements Data & Materials

[Standard Reference Materials | NIST](https://doi.org/10.1021/acs.iecr.2c04050)



<https://doi.org/10.1021/acs.iecr.2c04050>



Facilitate **traceability, rigor and reproducibility** across measurement ecosystems

## Documentary Standards

[Standards.gov](https://standards.gov) | [NIST](https://nist.gov)



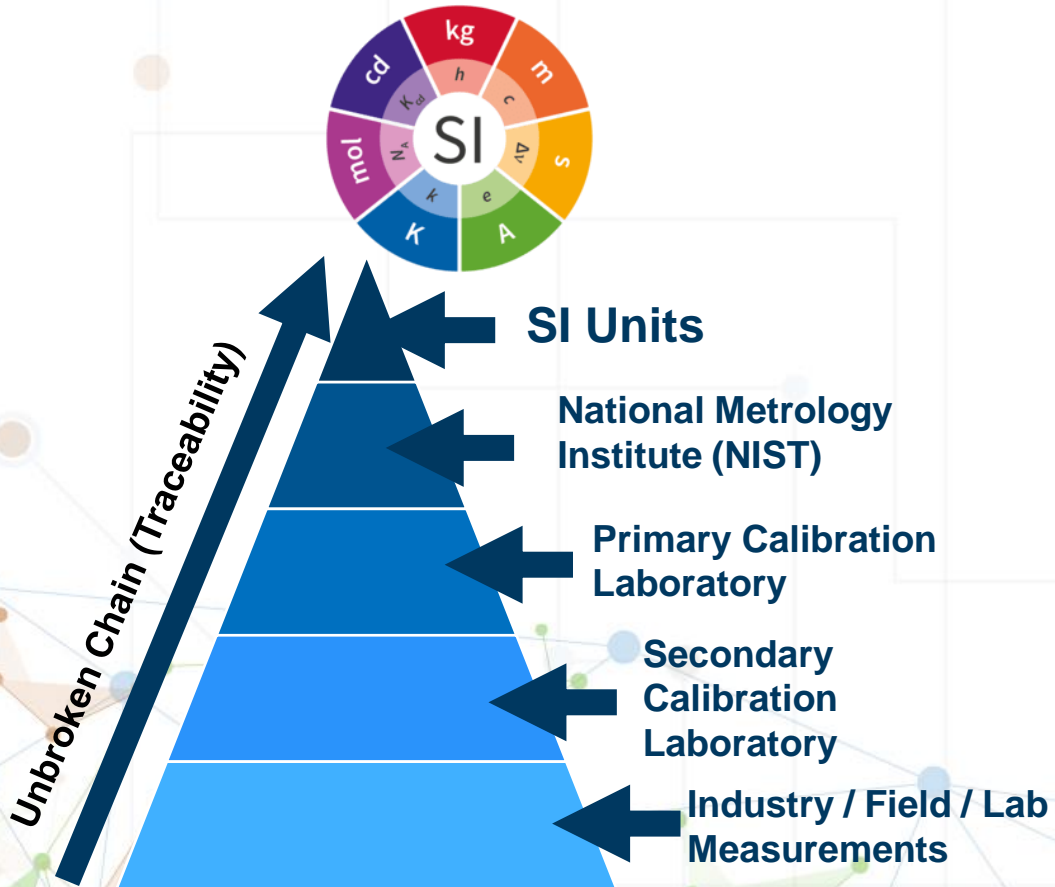
Support industry and government use of **voluntary consensus standards**



NATIONAL INSTITUTE OF  
STANDARDS AND TECHNOLOGY  
U.S. DEPARTMENT OF COMMERCE



# Measurement Quality



## Global Measurement Infrastructure:

- Traceability to the International System of Units
- Use of independent primary methods
- Comparisons with national metrology institutes (NMIs) across the globe

# Unique NIST Products and Services

**NIST**



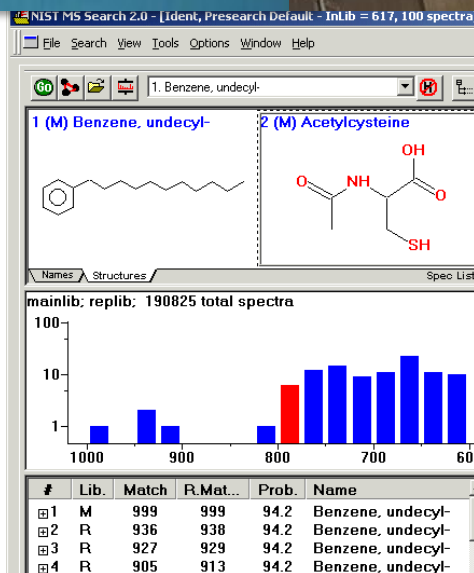
**1,200** Standard Reference Material (SRM) products

**100+** Standard Reference Data (SRD) products

**700** measurement services

[webbook.nist.gov](http://webbook.nist.gov)

**2M** views a month



<https://doi.org/10.18434/T4H594>

**Every year:**

**32,000** SRM units sold

**13,000** calibrations and tests

**800** accreditations of testing and calibrations laboratories

**20,000** SRD products downloaded or purchased

# Related Program Areas

## Measurements and Monitoring

### Greenhouse gases (GHGs) Carbon Dioxide Removal (CDR)

- Measurement traceability and technologies
- Ensuring data quality and standardization

## Decarbonization of the Economy

- Manufacturing
- Energy infrastructure
- Built environment
- Carbon capture, Utilization, and Sequestration (CCUS)

## Adaptation and Resilience

- Disaster and failure studies
- Wildland-Urban Interface fires
- Community resilience
- Connected systems resilience

**Life Cycle Analysis, Carbon Accounting**

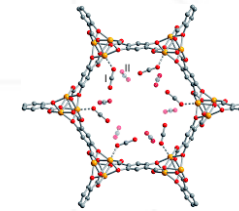


# Advancing Carbon Dioxide Removal

Examples of current focus areas include:

- [Direct Air Capture Sorbent Materials Characterization](#)
- [Low Carbon Cements and Concretes Consortium](#)
- [Next Generation Seawater CO<sub>2</sub> Reference Materials](#)
- [Ocean Color Satellite Calibration](#)
- [CO<sub>2</sub> Measurements and Reference Materials](#)
- [Forested Optical Reference for Evaluating Sensor Technology](#)
- Standards to Underpin MRV
- Standards and Conformity Assessment Considerations for Carbon Markets and Accounting
- CO<sub>2</sub> Pipeline Material Reliability
- Convergence with
  - [GHG Measurements](#)
  - [Circular Economy](#)

## Direct Air Capture Sorbent Materials Characterization

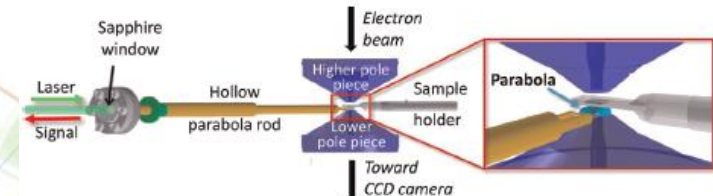
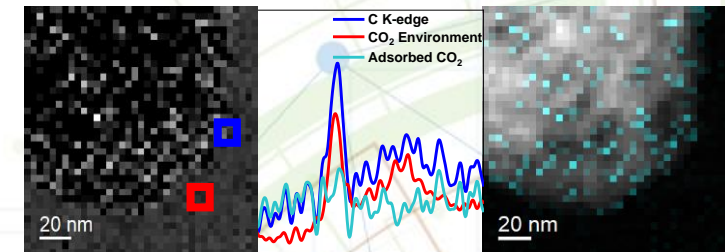


CO<sub>2</sub>-MOFs  
Structure




[Crystal structures nanosecond dynamics via neutron scattering](#)

CO<sub>2</sub> adsorption via in-situ STEM-EELS imaging



US Patent US9431211B2 Hybrid electron microscope; Ultramicroscopy 150, 10 (2015)  
Nature Materials 18 (6), 614–619 (2019)  
Microscopy and Microanalysis 27 (S1), 800-801 (2021)

# Seawater Carbon RM Production



Copies of this certificate and others can be obtained at:  
[https://www.nodc.noaa.gov/oceans/Dickson\\_CRM/batches.html](https://www.nodc.noaa.gov/oceans/Dickson_CRM/batches.html)

University of California, San Diego  
Scripps Institution of Oceanography  
Marine Physical Laboratory  
9500 Gilman Drive  
La Jolla, CA 92093-0244

### Certificate of Analysis

Reference material for oceanic CO<sub>2</sub> measurements

Batch 209 (Bottled 4/7/2023)

This reference material consists of natural sea water sterilized by a combination of filtration, ultra-violet radiation and addition of mercuric chloride.

**Analysis Results**

The various procedures used for these analyses are detailed overleaf.

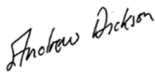
Salinity	33.147
Total dissolved inorganic carbon	2060.05 ± 0.36 μmol·kg <sup>-1</sup> (9; 9)
Total alkalinity	2210.40 ± 0.43 μmol·kg <sup>-1</sup> (32; 16)
Phosphate	0.50 μmol·kg <sup>-1</sup>
Silicate	3.8 μmol·kg <sup>-1</sup>
Nitrite	0.04 μmol·kg <sup>-1</sup>
Nitrate	5.9 μmol·kg <sup>-1</sup>

The cited uncertainties represent the standard deviation. Figures in parentheses are the number of analyses made (total number of analyses; number of separate bottles analysed). The nutrient levels may have changed on storage, their stability has not been examined. CO<sub>2</sub> analyses were performed over a period of time to confirm that the batch is stable.

The 95% confidence limits for the means of the certified analyses are thus:

Total dissolved inorganic carbon	2060.05 ± 0.27 μmol·kg <sup>-1</sup>
Total alkalinity	2210.40 ± 0.16 μmol·kg <sup>-1</sup>

**STORAGE:** The bottles should be stored out of direct sunlight, and preferably at or below room temperature (25 °C). They should not be allowed to freeze!



Andrew G. Dickson  
August 9, 2023



## MARINE RESEARCH

### Ocean scientists confront a critical bottleneck

The world's only source of essential seawater reference samples could soon close



Carefully characterized seawater samples have been key to marine research.

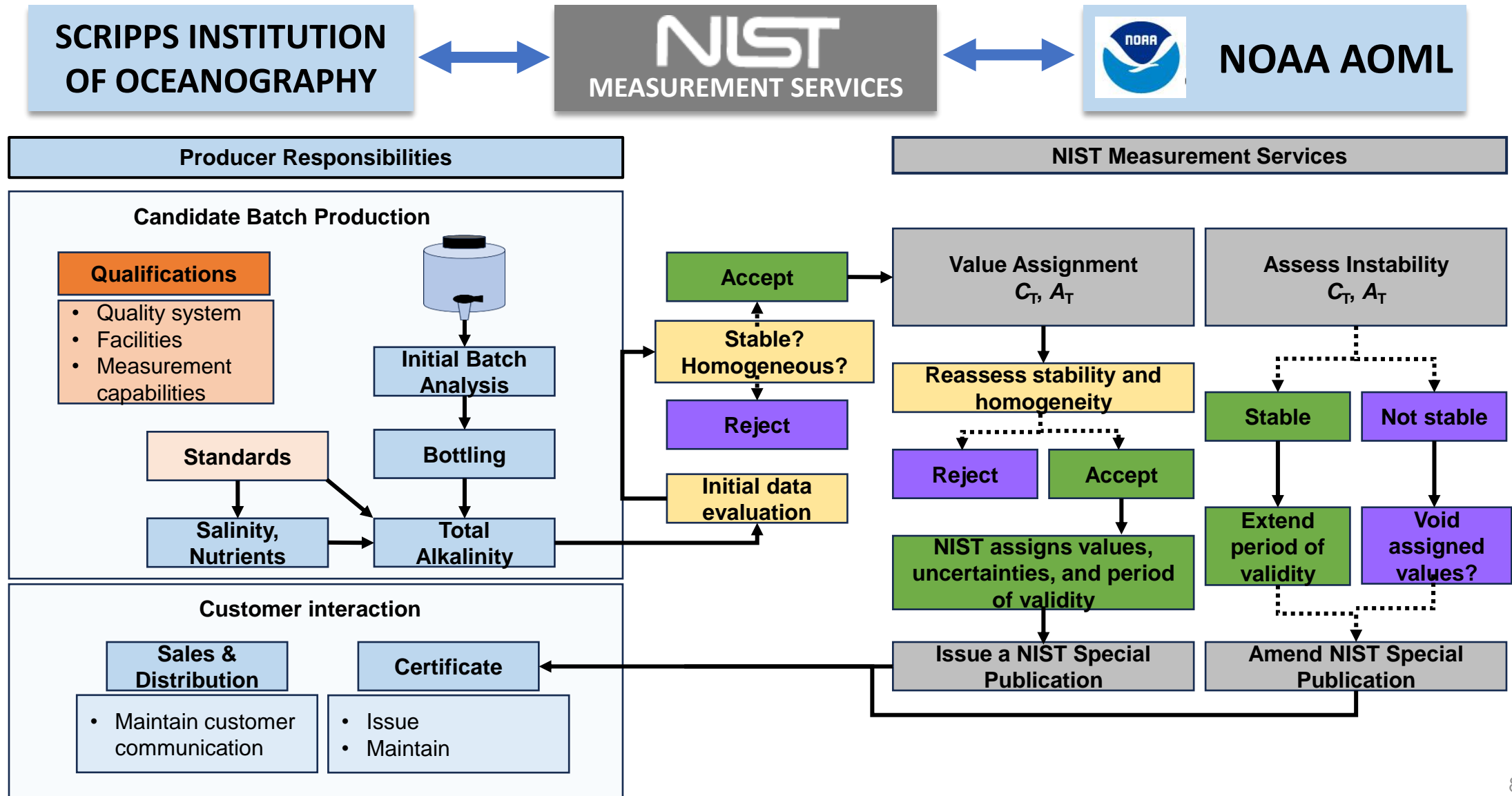
[science.org/doi/10.1126/science.acx9252](https://science.org/doi/10.1126/science.acx9252)

SCRIPPS INSTITUTION  
OF OCEANOGRAPHY

Global Customers  
(> 62 countries)

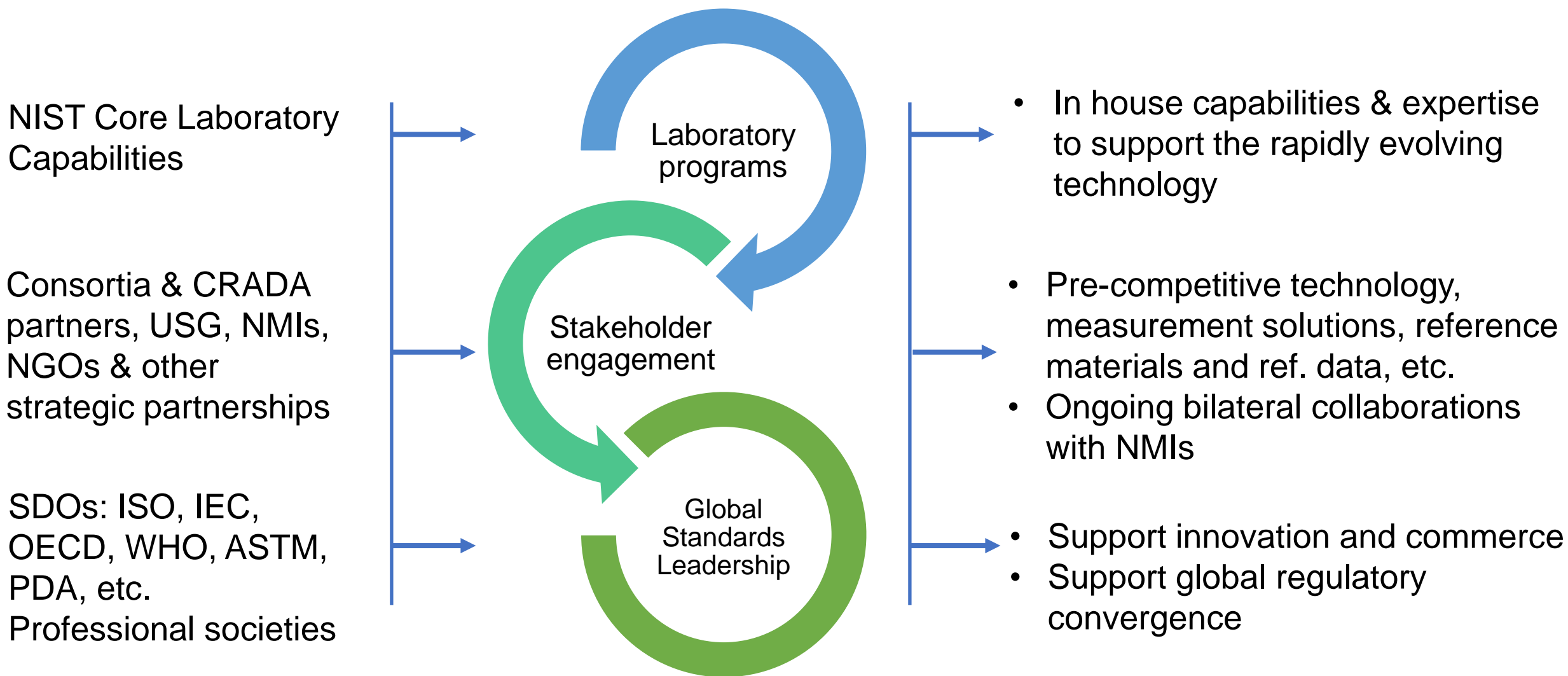
U.S. Customers  
(31 % of sales)

# Quality System Development





# From Laboratory Programs to Standards



# Example Consortia: Public-Private Partnerships to Address Pre-competitive Challenges towards Standards Development



**NIST Currently has - 24 Active Consortia; 691 Consortia CRADAs**



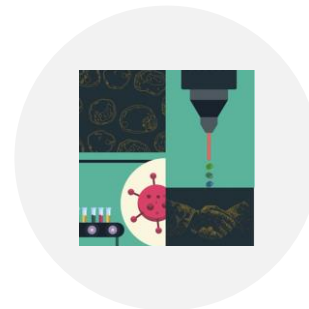
## **NIST GENOME IN A BOTTLE (GIAB) CONSORTIUM**

Provides authoritative characterization of benchmark human genomes



## **NIST GENOME EDITING CONSORTIUM\***

Develops measurement solutions and standards needed to increase confidence and reduce risk  
**Formal members: 47**



## **NIST FLOW CYTOMETRY STANDARDS CONSORTIUM\***

Accelerates the adoption of quantitative flow cytometry in biomanufacturing  
**Formal members: 33**



## **NIST RAPID MICROBIAL TESTING METHODS CONSORTIUM**

Addresses measurements and standards needed to increase confidence in the use of rapid testing  
**Formal members: 44**

# Low Carbon Cements and Concretes Consortium



- ▷ Accelerate adoption of innovative low-carbon building materials – Cements & Concretes
- ▷ Initiated in 2022 –
- ▷ 52 Member Organizations - Private and Public Sectors
- ▷ Coordinates with voluntary consensus standards organizations, e.g. ASTM
- ▷ Facilitate standards development, interlaboratory comparisons, reference materials
- ▷ Coordinate with other agencies EOP, DOE, EPA, DOT

- AIA
- Argos
- ASCC
- Ash Grove
- Biomason
- Blue Planet Systems
- Boise State Univ.
- Brimstone
- Buchi
- Building Transparency
- Bureau of Reclamation
- CalPortland Company
- CarbiCrete
- Carbon Limit
- CarbonBuilt
- CarbonCure
- CMHA
- Continental Cement
- DOE
- EPA
- FHWA
- Fortera
- Georgetown Univ.
- Georgia Tech.
- Heidelberg Materials
- Holliday Rock
- Iowa State
- Kiewit
- Kline Consulting, LLC
- MIT - Concrete Sustainability Hub
- NEU
- NETL
- NIBS
- NRMCA
- NSF
- Outside the Box Materials
- Ozinga
- PCA
- Purdue Univ.
- Spherical Block, LLC
- St Mary's Cement
- Sublime Systems
- Sutter Engineering
- U.S. Army Corp of Engineers
- UC Davis
- UCLA
- Ultra High Materials, Inc
- Univ. of Miami
- Univ. Texas at Arlington
- WAP Sustainability
- WR Meadows
- WRI



# Meeting Schedule



## Steering Group

*Twice per year  
and as needed  
(online)*



## 4 Working Groups

*Once every two  
months (online)*

*Quantifying carbonates  
Performance specifications  
Carbon Accounting  
Innovative Materials*



## Full Consortium

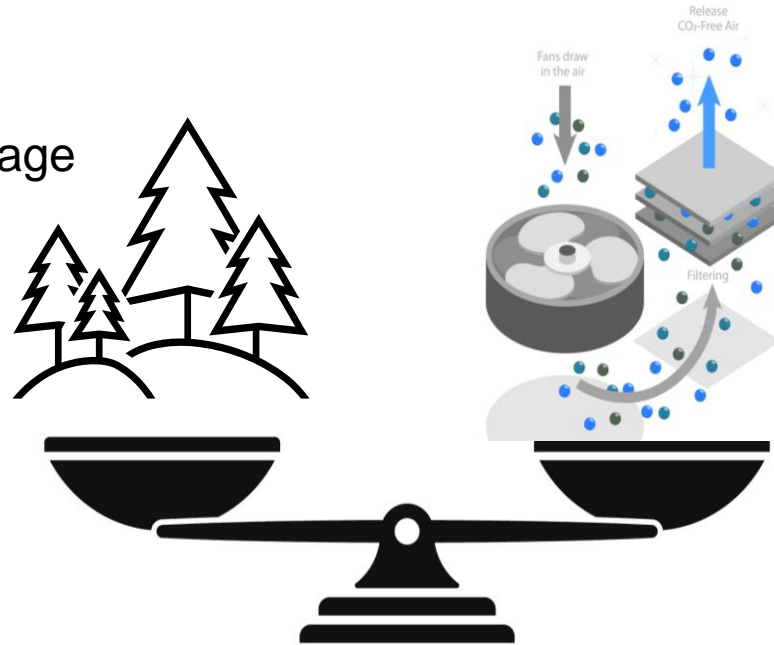
*ACI Spring &  
Fall Conventions*

*Standalone Event  
(1-2 days) in July*



## Pathways

- **Afforestation, Reforestation, Improved Forest Management**
- Blue Carbon Management
- Biochar
- Biomass Carbon Removal & Storage
- **Direct Air Capture & Storage**
- Direct Ocean Capture & Storage
- Enhanced Rock Weathering
- Ocean Alkalinity Enhancement
- Ocean Fertilization
- Peatland and Coastal Wetland Restoration
- Soil Carbon Management
- Etc.



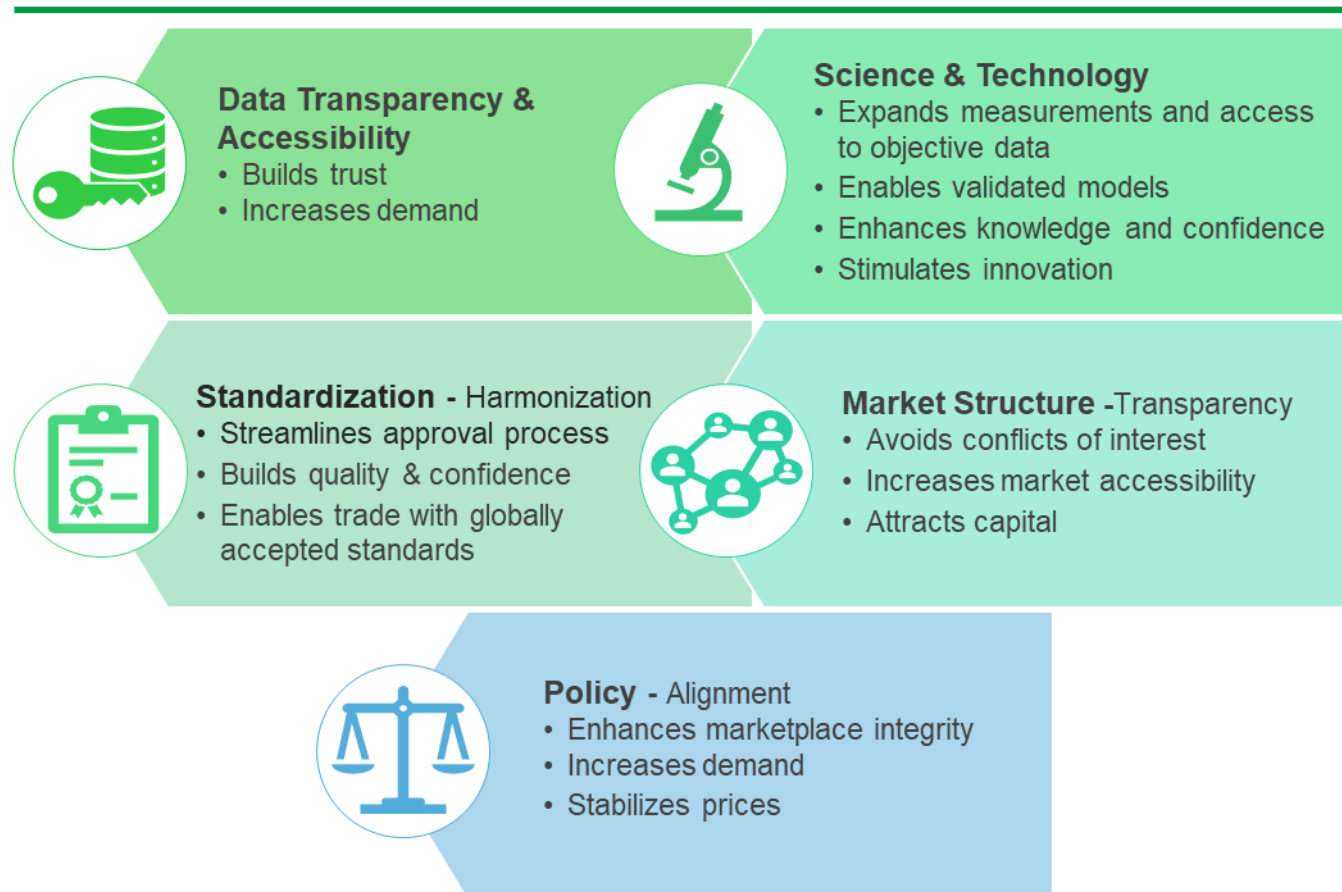
## Additional Attributes

- Permanence
- Additionality
- Leakage
- Sustainability
- Development Goals
- Etc.

## Challenges



## Opportunities





# Carbon Dioxide Removal Consortium



## Initial Stakeholder Engagement:

- Georgetown Workshop Sept 2023
- 1-on-1 discussions
- North American Carbon World-March 2024
- SF Climate Week – April 2024



Increase the market efficiency and scale with measurements and standards

- ▷ Carbon Dioxide Removal Consortium - Initiated in 2024
- ▷ Precompetitive and CRADA-Based
- ▷ On-boarding phase; Meetings to commence early 2025
- ▷ Initial Focus 1) Direct Air Capture and 2) Forests
- ▷ Inquiries – email [CO2removal@nist.gov](mailto:CO2removal@nist.gov)

# Partnerships, Engagement & Convening

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NIST is growing partnerships & convening stakeholders to help build trusted MRV and carbon accounting.

- Quantify CDR across engineered and nature-based pathways.
- Enable measurement comparability for informed CDR and CCUS decisions
- Promote equitable trade

[lowcarbonconcrete@nist.gov](mailto:lowcarbonconcrete@nist.gov)  
[CO2removal@nist.gov](mailto:CO2removal@nist.gov)  
[Pamela.chu@nist.gov](mailto:Pamela.chu@nist.gov)