
SIM.M.M-S21

Comparison of mass standards

SUPPLEMENTARY COMPARISON

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SIM.M.M-S21 – FINAL REPORT

SUPPLEMENTARY MASS COMPARISON WITHIN SIM CARIMET NMIs

1. General Information

This supplementary comparison is being carried out among five (5) SIM NMIs in order to compare the degree of equivalence in the calibration of high accuracy mass standards.

2. Data of the National Metrology Institutes and Technical Contacts for the Comparison

The participant NMIs to this mass comparison are listed in Table 1. Jamaica being the only signatory and the other participants are designated institutes under CARICOM.

Table 1 : Participant National Metrology Institutes

1	National Metrology Institute	Bureau of Standards of Jamaica (BSJ)
	Technical Contacts	Carl Hall
	Address	6 Winchester Road, Kingston 10, Jamaica, W.I.
	Phone / Fax	(876) 926-3140-5 ext. 3016
	Email	chall@bsj.org.jm
2	National Metrology Institute	Centro Nacional de Metrología (CENAM)
	Technical Contacts	Luis Manuel Peña Pérez
	Address	km 4.5 Highway to Los Cués, El Marqués Municipality, Querétaro, Mexico 76246
	Phone / Fax	(+52) 442.211.05.00 ext. 3604
	Email	lpena@cenam.mx
3	National Metrology Institute	Guyana National Bureau of Standards (GNBS)
	Technical Contacts	Edward Melville
	Address	Flat 15 Exhibition Complex, Sophia, Georgetown
	Phone / Fax	011-592-219-0062/64/66
	Email	emelville@gnbsgy.org
4	National Metrology Institute	Saint Lucia Bureau of Standards (SLBS)
	Technical Contacts	Anselm Gittens
	Address	National Agricultural Diagnostic Facility (NADF), Union, P.O. Box CP 5412, LC-Castries Saint Lucia, W.I.
	Phone / Fax	1-758-453-0049, 1-758-456-0546
	Email	a.gittens@slbs.org
5	National Metrology Institute	Trinidad and Tobago Bureau of Standards (TTBS)
	Technical Contacts	Frederick King
	Address	1-2 Century Drive, Trincity Industrial Estate Macoya, Tunapuna, Trinidad, W.I.
	Phone / Fax	(868) 662-TTBS (8827), 4481/2, 663-4835/6; ext. 2309
	Email	frederick.king@ttbs.org.tt

3. General Considerations and Procedure

In order to evaluate the degree of equivalence amongst SIM NMIs in calibration of mass standards of Class E₂, a supplementary mass comparison was planned among five National Metrology Institutes from the SIM region.

The goal is to evaluate the degree of equivalence between participant results on the calibrations of stainless-steel weights in conventional mass value.

For this comparison, BSJ agreed to act as Pilot Laboratory and CENAM-Mexico accepted to be the Support Laboratory.

A set of mass standards, property of the BSJ and TTBS, will be used for this comparison.

These travelling standards have the following nominal values and identification (see table 2):

Table 2: Set of Travelling Standards.

Nominal value	ID No.	Serial No.	Manufacturer	
5 kg	-	16914	Troemner	TTBS
2 kg	A	1321008	Häfner	BSJ
1 kg	A			
200 g	A			
50 g	A			
200 mg	Hook			

The travelling standards were circulated amongst all participating laboratories.

When the travelling standards arrived at each participating laboratory, a visual inspection was done on of the surfaces, and the findings were recorded.



... **Fig. 1: BSJ travelling standards.**



Fig. 2: TTBS travelling standard.

The travelling standards must always be handled with tweezers, pincers, lifters but never with bare hands. Acid free or lint free paper is also provided.

Values for the density and volume of the travelling standards were measured by CENAM.

Table 3. Density of travelling standards

Nominal value	Density, ρ	$U(\rho), k = 2$
5 kg	8 033.1 kg/m ³	1.5 kg/m ³
2 kg	8 010.1 kg/m ³	1.5 kg/m ³
1 kg	8 006.7 kg/m ³	0.3 kg/m ³
200 g	8 006.0 kg/m ³	1.5 kg/m ³
50 g	8 013.3 kg/m ³	1.8 kg/m ³
200 mg	8 000 kg/m ³	80 kg/m ³

Table 4. Volume of travelling standards

Nominal value	Volume, V	$U(V), k = 2$
5 kg	622.43 cm ³	0.12 cm ³
2 kg	249.686 cm ³	0.047 cm ³
1 kg	124.896 1 cm ³	0.044 cm ³
200 g	24.981 2 cm ³	0.004 7 cm ³
50 g	6.239 6 cm ³	0.001 4 cm ³
200 mg	0.025 00 cm ³	0.000 25 cm ³

Regarding the magnetic properties of the weights, all the travelling standards are in accordance with specifications for class OIML E₂.

4. Transportation

The travelling standards were circulated among participants according to the schedule shown in table 5.

Table 5: Circulation of the travelling standards

No.	National Metrology Institute	Expected Arrival	Sending of results
1.	CENAM – Mexico	Oct 23 rd	Dec 12 th 2023
2.	BSJ – Jamaica	Jan 8 th	Jan 22 nd 2024
3.	SLBS – Saint Lucia	Mar 6 th	Mar 21 st 2025
4.	TTBS – Trinidad and Tobago	May 21 st	Jul 25 th 2024
5.	GNBS – Guyana	Jun 10 th	Jun 28 th 2024
6.	BSJ – Jamaica	Sept 6 th	(Draft A report) – Jun 16 th 2025

Results

Each participant reported the conventional mass difference from nominal value (Δm_c = conventional mass value – nominal value) and the uncertainty associated to each travelling standard. Values as reported by participants are listed in Tables 6 and in figures 3 to 8.

Table 6. The table gives conventional mass differences from nominal value for travelling standards as reported by participants.

	CENAM		BSJ ₁		SLBS		GNBS		BSJ ₂		TTBS	
	Δm_c mg	$U, k = 2$ mg	Δm_c mg	$U, k = 2$ mg	Δm_c mg	$U, k = 2$ mg	Δm_c mg	$U, k = 2$ mg	Δm_c mg	$U, k = 2$ mg	Δm_c mg	$U, k = 2$ mg
200 mg	0.006 0	0.001 4	0.005 4	0.003 0	0.009 5	0.020	0.005 5	0.014	0.005 8	0.003 0	0.006 6	0.004 6
50 g	0.015	0.009 6	0.013	0.013	0.034	0.086	0.005 2	0.037	0.011	0.012	0.020	0.027
200 g	-0.026	0.021	-0.019	0.035	-0.022	0.27	-0.052	0.12	-0.017	0.035	0.006 0	0.085
1 kg	0.56	0.067	0.51	0.19	2.2	4.4	0.52	0.56	0.60	0.19	0.62	0.44
2 kg	-0.11	0.27	0.28	0.36	0.75	5.0	-0.20	1.0	0.27	0.85	-0.43	0.85
5 kg	1.5	0.87	2.1	0.93	1.9	8.3	0.95	2.8	2.1	0.93	1.9	2.3

For this comparison, all participating NMIs agreed that the CENAM results should be considered as providing the reference values, so the results of the participating NMIs from SIM-CARIMET, i.e. BSJ, TTBS, SLBS and GNBS, were compared with the CENAM results. No drift correction was done during the transfer of the standards and it was assumed the standards were stable during circulation.

NOTE: For this comparison, CENAM has used a measurement system different from the calibration of weights employed to obtain the uncertainties published in the KCDB. The uncertainty results provided by CENAM are lower than 1/3 of the maximum permissible error (*mpe*) for the OIML Class E₁ accuracy class, except for the 5 kg weight, which is slightly larger than 1/3 *mpe* OIML Class E₁.

The Saint Lucia Bureau of Standards (SLBS) was initially scheduled to participate in the Supplementary Mass Comparison as the first laboratory to receive the travelling standards after the Pilot and Support Laboratories. In accordance with the comparison protocol, SLBS was expected to submit its measurement results within the specified timeframe. Despite multiple reminders and follow-ups, no results were received during the designated period. As a result, SLBS's data was not included in the initial draft A comparison report sent to CENAM for review. However, their results were submitted before Draft A was circulated among the participants. We therefore cannot verify the authenticity of the results received one year after it was scheduled to be received.

Given this development the Draft A report was revised to incorporate the newly received data which caused a delay in circulation of the report by four (4) months.

Figure 3. Results reported by participant laboratories for the 5 kg weight.

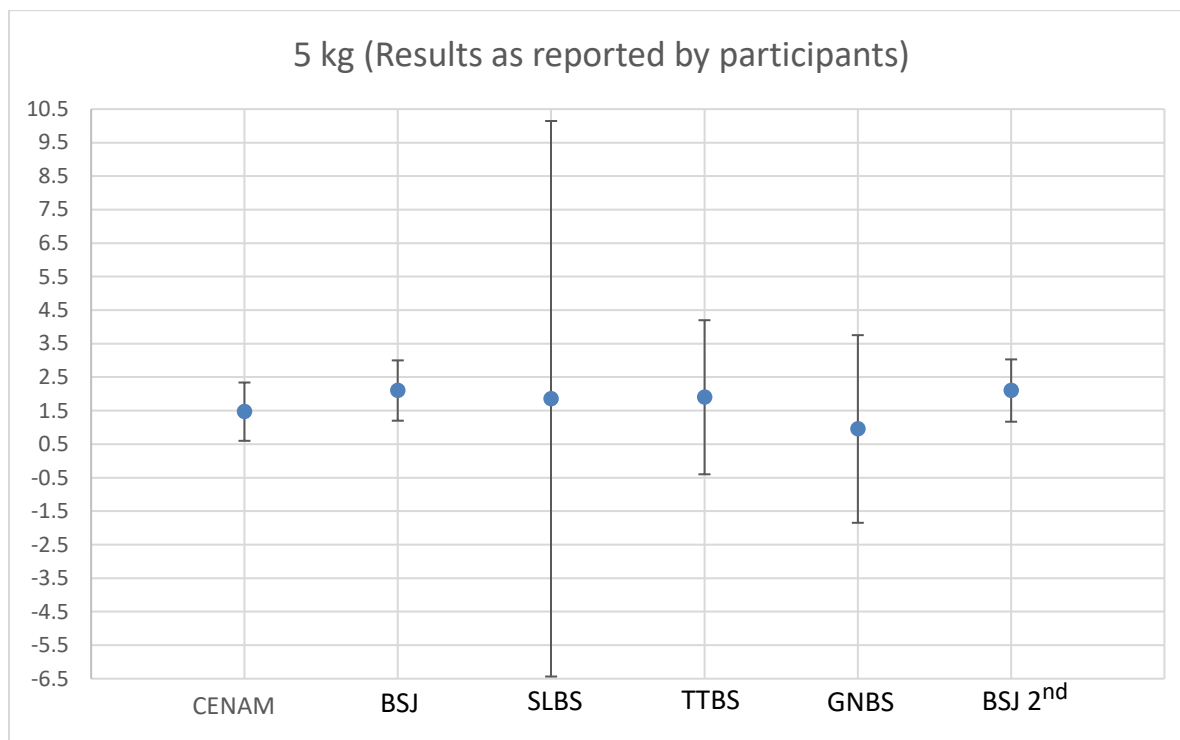


Figure 4. Results reported by participant laboratories for the 2 kg weight.

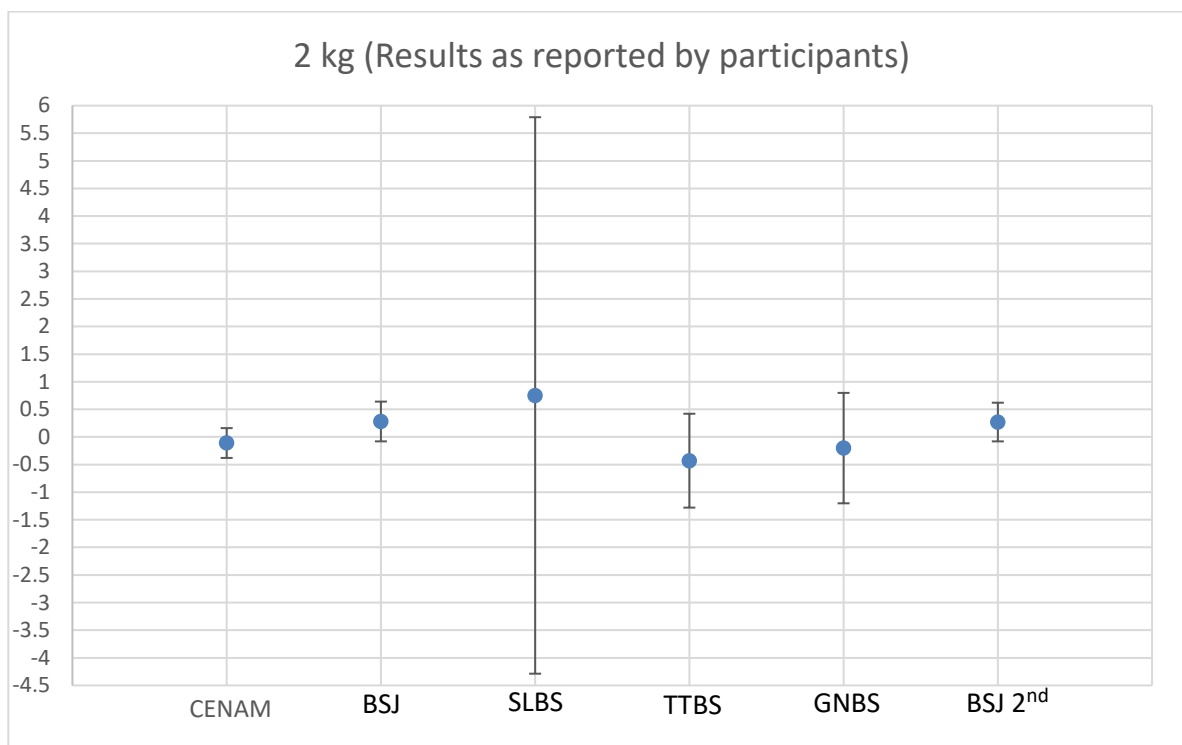


Figure 5. Results reported by participant laboratories for the 1 kg weight.

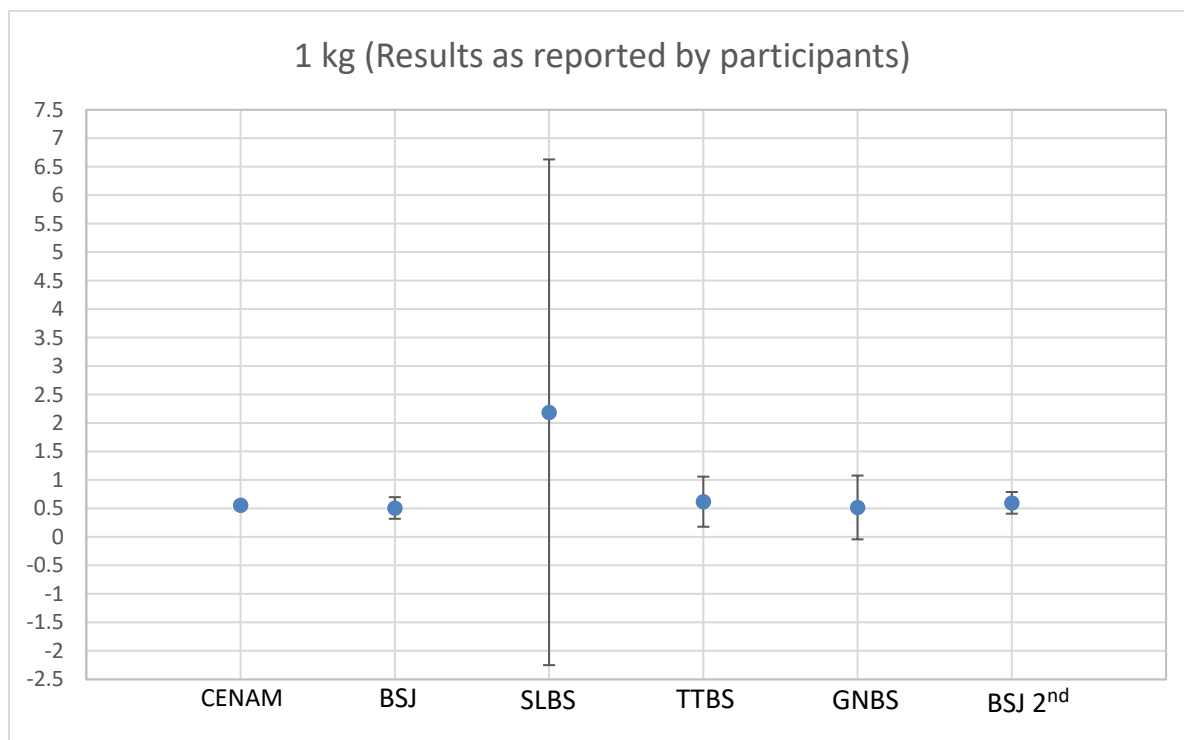


Figure 6. Results reported by participant laboratories for the 200 g weight.

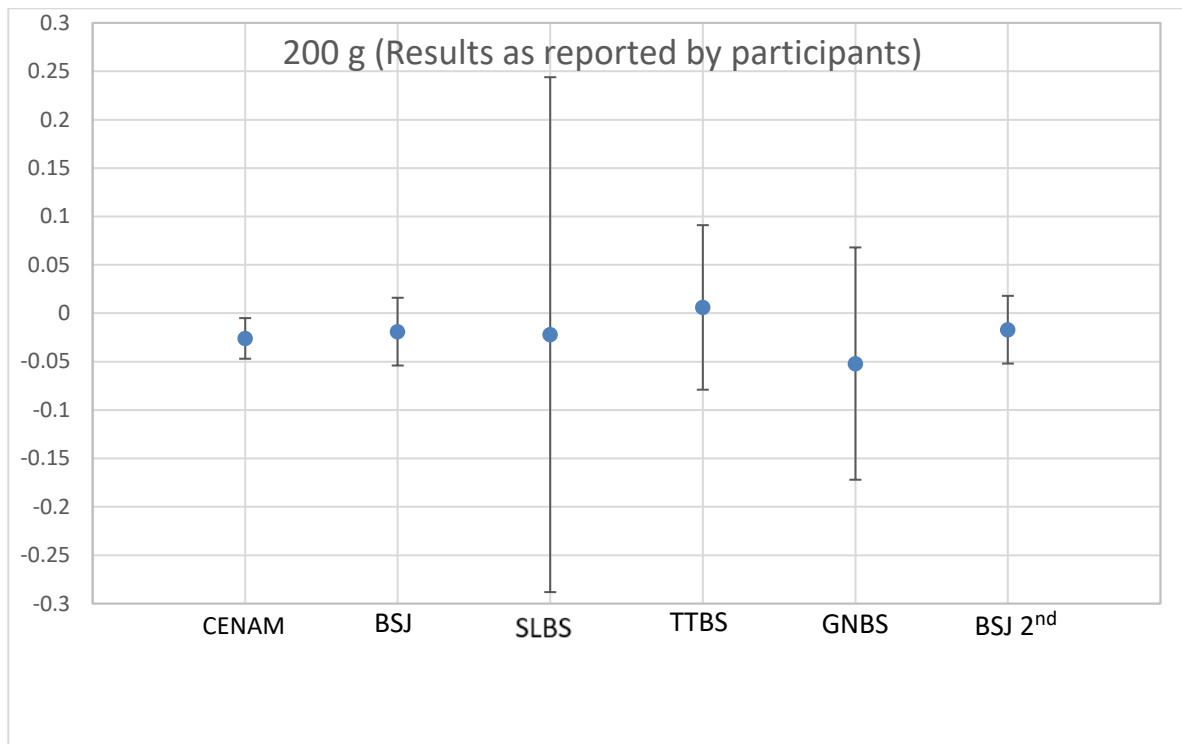


Figure 7. Results reported by participant laboratories for the 50 g weight.

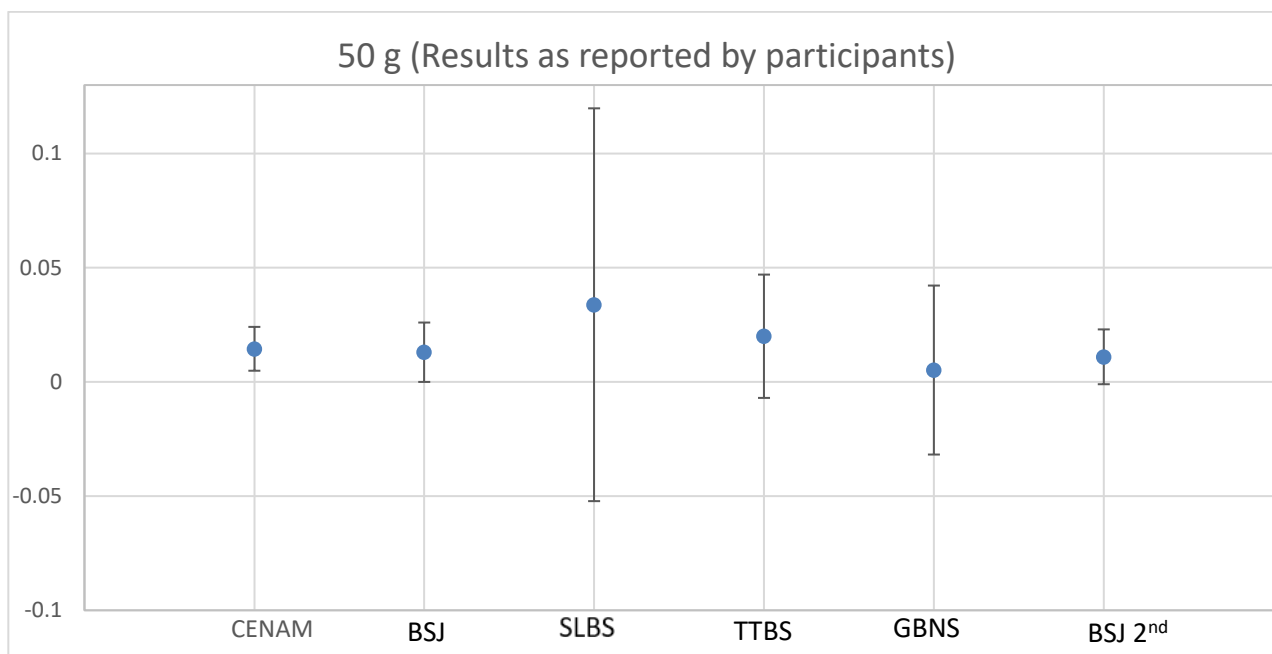
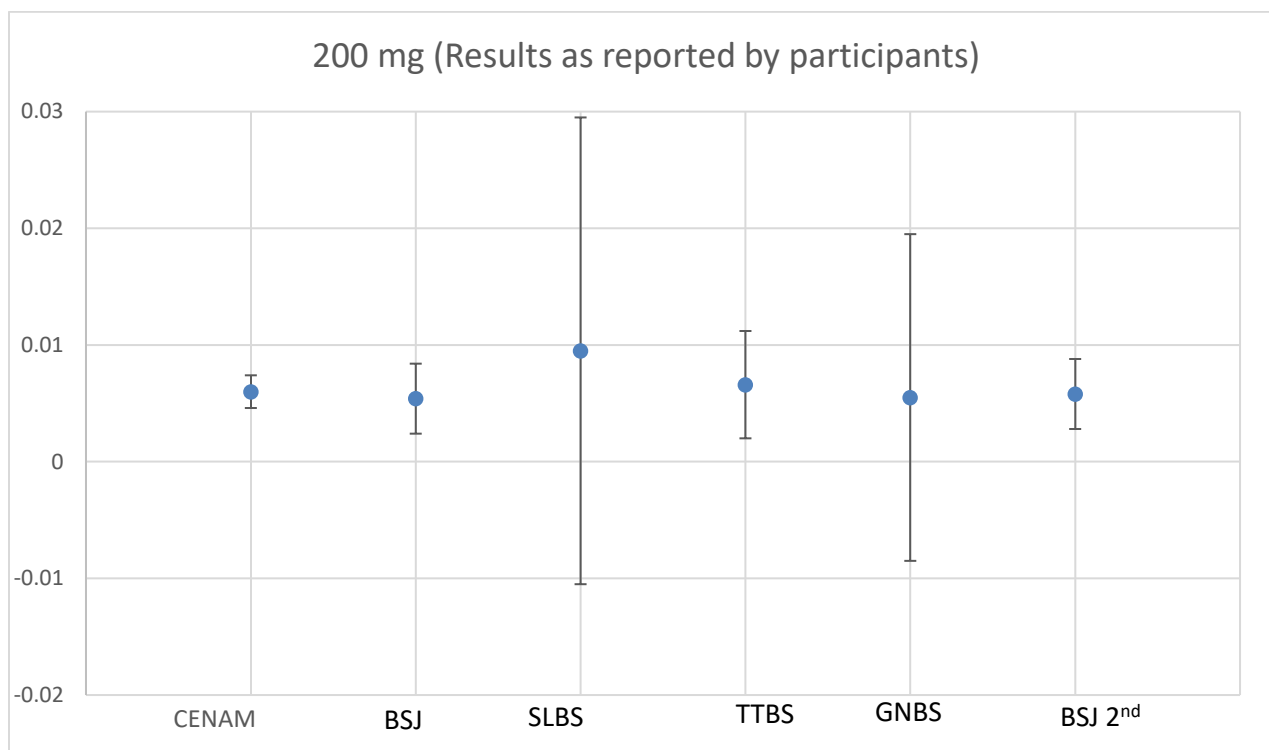


Figure 8. Results reported by participant laboratories for the 200 mg weight.



Degree of Equivalence (DoE)

The degree of equivalence D among participant laboratories was calculated as follows:

$$D_{\text{NMI}} = X_{\text{CENAM}} - X_{\text{NMI}} \quad (3)$$

with the expanded uncertainty as follows,

$$U(D)_{\text{NMI}} = 2 \times [u^2(X)_{\text{CENAM}} + u^2(X)_{\text{NMI}}]^{1/2} \quad (4)$$

From this difference and corresponding uncertainty, the normalized errors were calculated for each nominal value as follows,

$$E_n = D_{\text{NMI}} / U(D)_{\text{NMI}} \quad (5)$$

Where:

- X_{CENAM} is the conventional mass error of CENAM
- X_{NMI} is the conventional error of the individual participating laboratories.
- $U(X_{\text{CENAM}})$ is the uncertainty reported by the CENAM at 95% confidence level
- $U(X_{\text{NMI}})$ is the uncertainty of the participating laboratories value at 95% confidence level
- E_n is the normalized error of the results

Table 7. Degree of Equivalence between NMIs and CENAM and normalized error

	5 kg			2 kg			1 kg			200 g			50 g			200 mg		
NMIs	D mg	$U(D)$ ($k = 2$) mg	E_n	D mg	$U(D)$ ($k = 2$) mg	E_n	D mg	$U(D)$ ($k = 2$) mg	E_n	D mg	$U(D)$ ($k = 2$) mg	E_n	D mg	$U(D)$ ($k = 2$) mg	E_n	D mg	$U(D)$ ($k = 2$) mg	E_n
BSJ ₁	-0.63	2.6	0.25	-0.39	0.48	0.82	0.046	0.18	0.13	-0.007 0	0.056	0.13	0.001 5	0.017	0.090	0.000 60	0.005 0	0.090
TTBS	-0.43	4.9	0.090	-0.32	1.6	0.20	-0.064	0.43	0.070	-0.032	0.17	0.19	-0.005 5	0.050	0.11	-0.000 6	0.009 0	0.060
GNBS	0.60	5.9	0.090	-0.34	1.9	0.050	0.046	0.56	0.030	-0.078	0.24	0.11	0.009 5	0.071	0.13	0.001 0	0.028	0.020
BSJ ₂	-0.63	2.6	0.25	-0.38	0.45	0.85	-0.044	0.18	0.12	-0.009 0	0.056	0.16	0.003 5	0.014	0.24	0.000 20	0.005 0	0.030
SLBS	-0.39	16	0.020	-0.86	10	0.090	-1.6	4.4	0.18	-0.003 9	0.53	0.010	-0.019	0.17	0.11	-0.003 5	0.040	0.090



SIM.M.M-S21 – Final Report Supplementary Mass Comparison among SIM CARIMET NMIs



Conclusions

The main objective of this SIM comparison was to evaluate the degree of equivalence between CENAM-Mexico, SLBS-St. Lucia Bureau of Standards, TTBS-Trinidad & Tobago, GNBS-Guyana Bureau of Standards and BSJ-Jamaica in the calibration of mass standards.

In order to reach these objectives, six (6) stainless steel weights were measured in each country's respective laboratory from October 2023 to May 2024.

For the measurements, each laboratory used their own facilities, equipment, mass standards and procedures.

From results reported by participants (see Table 6), the degree of equivalence between participants in the scope range of this comparison as well as the normalized errors were calculated. Results are reported in Table 7. All the laboratories submitted their results as scheduled except for SLBS.

From the data in Table 7, it can be noted that results reported by the participants are consistent within the reported uncertainty. The largest normalized error calculated for this comparison was 0.85.

Reference

- [1] JCGM 100:2008. "Evaluation of measurement data — Guide to the expression of uncertainty in measurement". (2008)
- [2] OIML R 111-1 Edition 2004 (E): International Recommendation – Weights of classes E₁, E₂, F₁, F₂, M₁, M₁₋₂, M₂, M₂₋₃ and M₃. Part 1: Metrological and technical requirements
- [3] ZMK "Comparison measurements Introduction and procedures with examples" (2024)