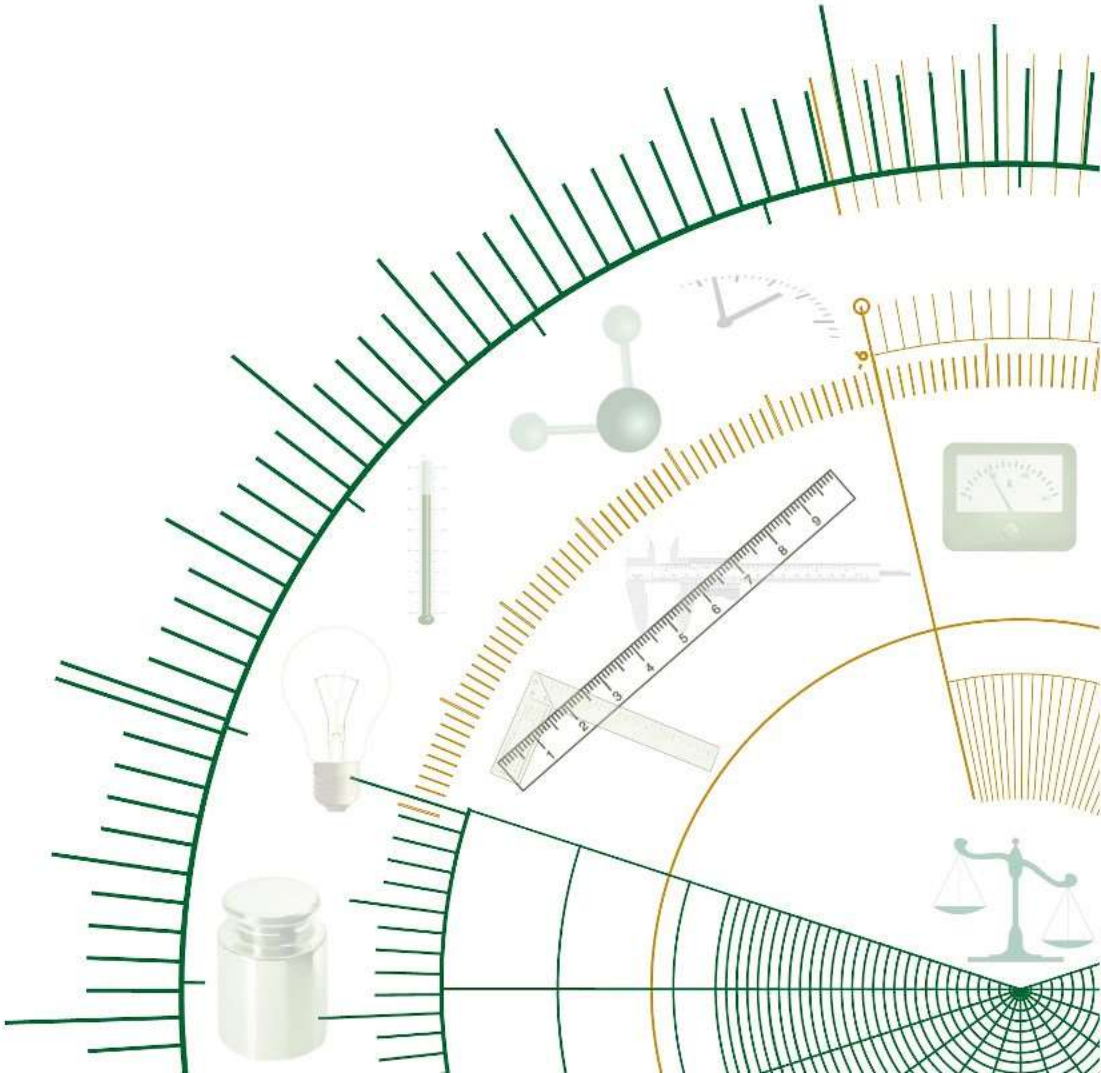
Standards for space

Rheinhardt Sieberhagen

National Space Conference 2023

Your measure of excellence



Introduction

- NMISA is mandated by the Measurement Units and Measurement Standards Act, Act 18 of 2006, “To apply the International System of Units (SI) in South Africa and maintain and disseminate the National Measurement Standards (NMS)”.
- NMISA is one of the DTIC’s Technical Infrastructure institutes.

- Technical laboratories:
  - Chemical Material and Medical Metrology
  - Physical and Electrical Metrology
  - Applied Metrology

Physical and Electrical Metrology

Flow	**Length**	**Photometry and Radiometry**	**Mass**	**Force**
Acoustics, Ultrasound and Vibration	**Pressure**	**DC Low Frequency and Radio Frequency**	**Temperature and Humidity**	**Torque**

Metrology?

The science of measurement; including all theoretical and practical aspects

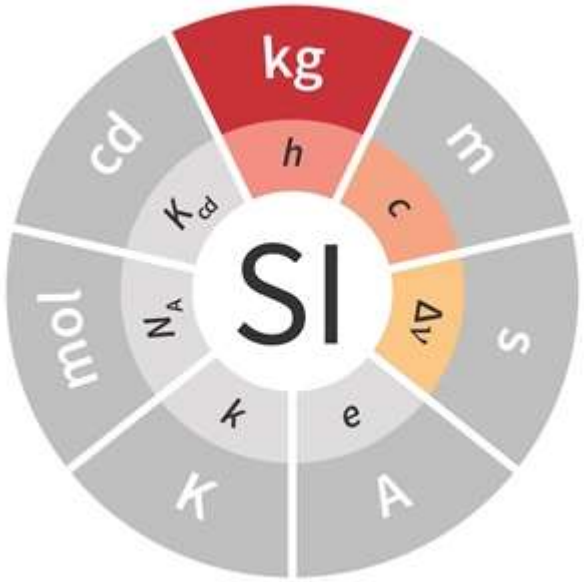
Measurement?

Process of experimentally obtaining one or more values attributed to a quantity.

Example: the mass (quantity) m of an object is measured once as m = 1 kg.

Role of metrology?

Link measurements to the SI units; ensure international traceability, with an assigned uncertainty.



NMISA's role in SA?

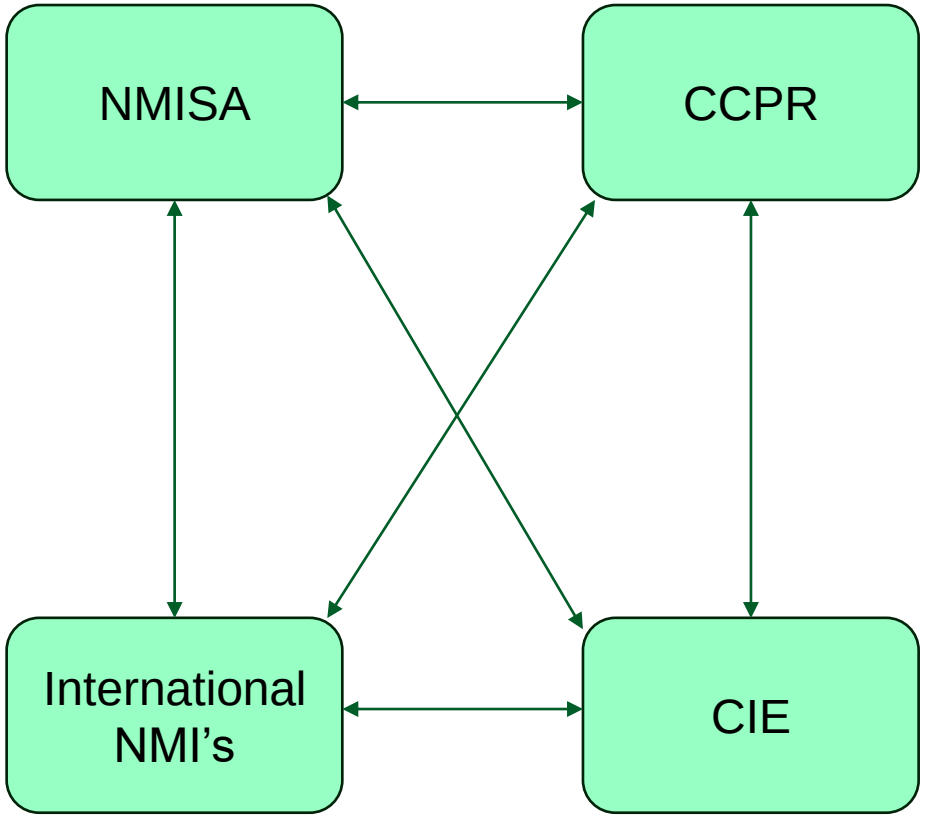
To provide calibration and measurement services to SA industry, traceable to international standards.

Calibration?

Comparison of measurement values produced by a device under test to a known value provided by an internationally defined calibration standard of known accuracy.

Standard?

- A measuring system or device (*i.e. equipment standards).*
- Documented principles/methods/procedures describing how to use equipment standards when performing a measurement.
- “Document” standards set up by international experts that interact through various international committees and working groups.



Calibration

Traceability

Traceability: “a 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”.

International vocabulary of metrology

Uncertainty of measurement

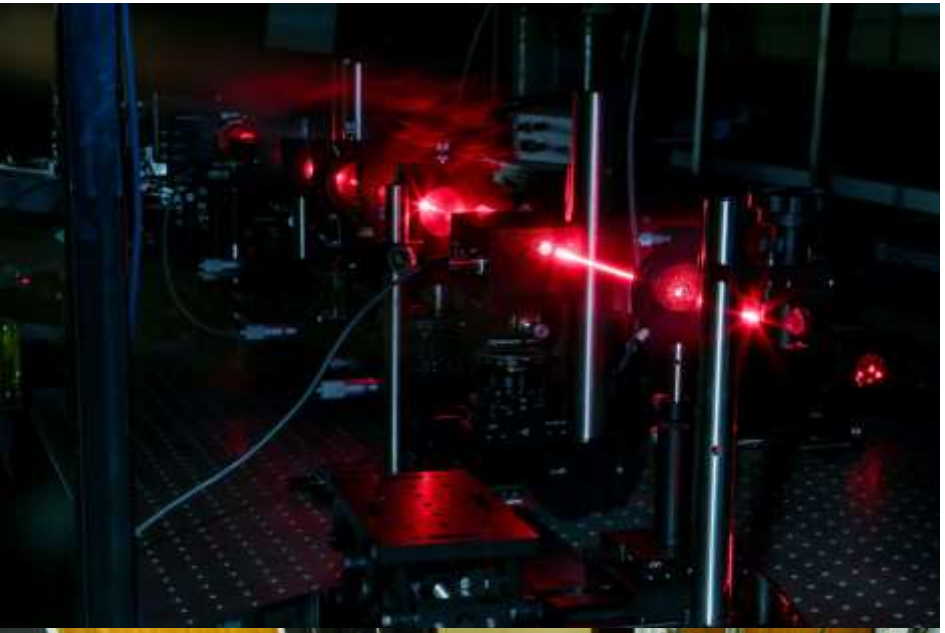
Uncertainty can be described as the doubt that exists about the result of a measurement.

A calibration certificate typically reports the following:

“The mass of the mass piece is 1,00 kg ± 0,01kg, at a confidence level of 95 %”.

This means that the true value of the mass lies somewhere between 0,99 kg and 1,01 kg and that we are 95 % sure of that.

Space standards



UNCERTAINTY BUDGET MATRIX (UBM)

Certificate No	TBC
Procedure No	OR\SR-0007 & OR\SR-0014
Date	15/07/2021

Reference: Guide to the Expression of Uncertainty in Measurement, issued by BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML - ISO 1995 (ISBN 92-67-10188-9)

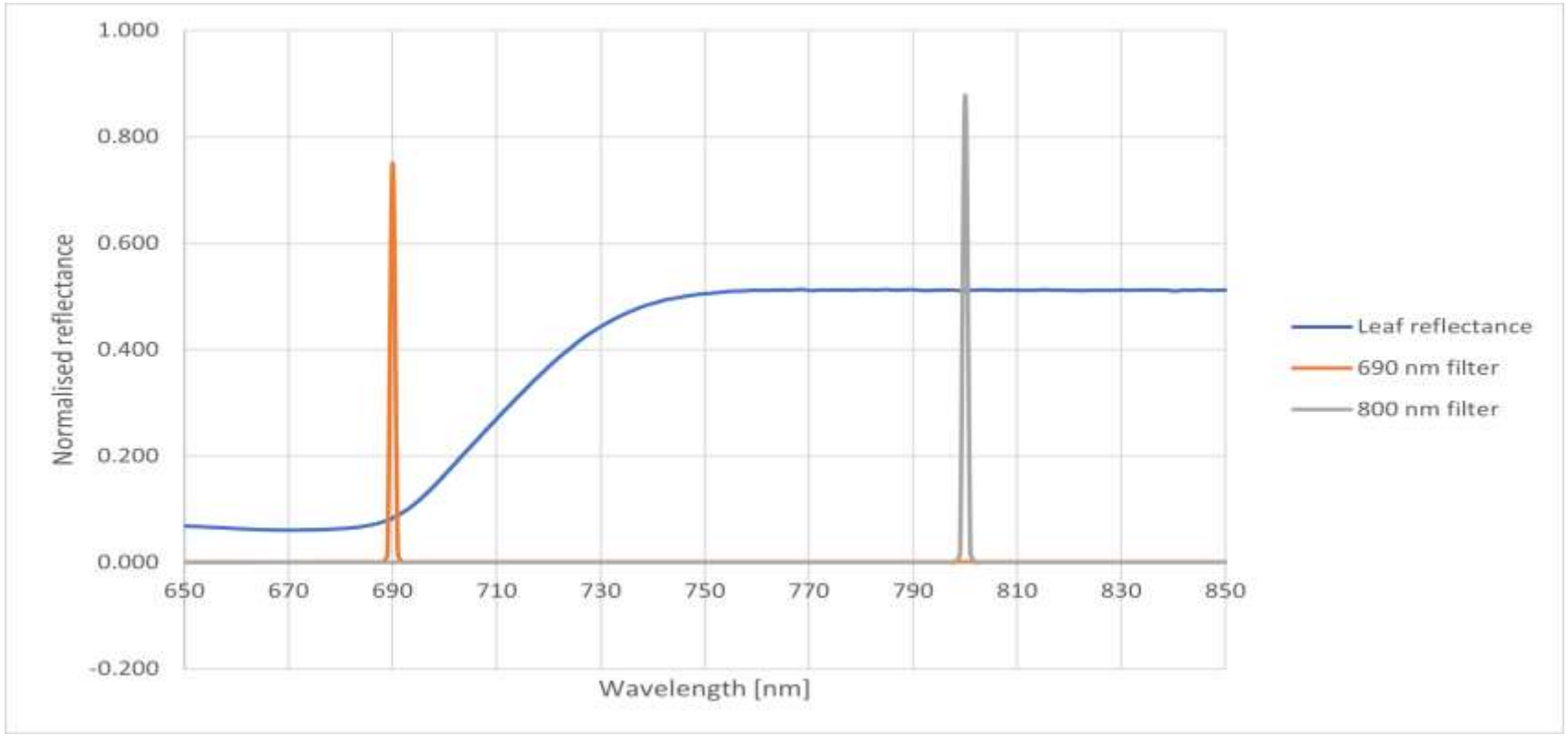
Description:	Wavelength verification of spectroradiometer	Type & Serial Number	Photo Research PR735 (ORW-007.SR). S/N: 73141801	Range:	380 nm to 1 080 nm and 14 nm bandwidth	Metrologist	IR

Mathematical Model:

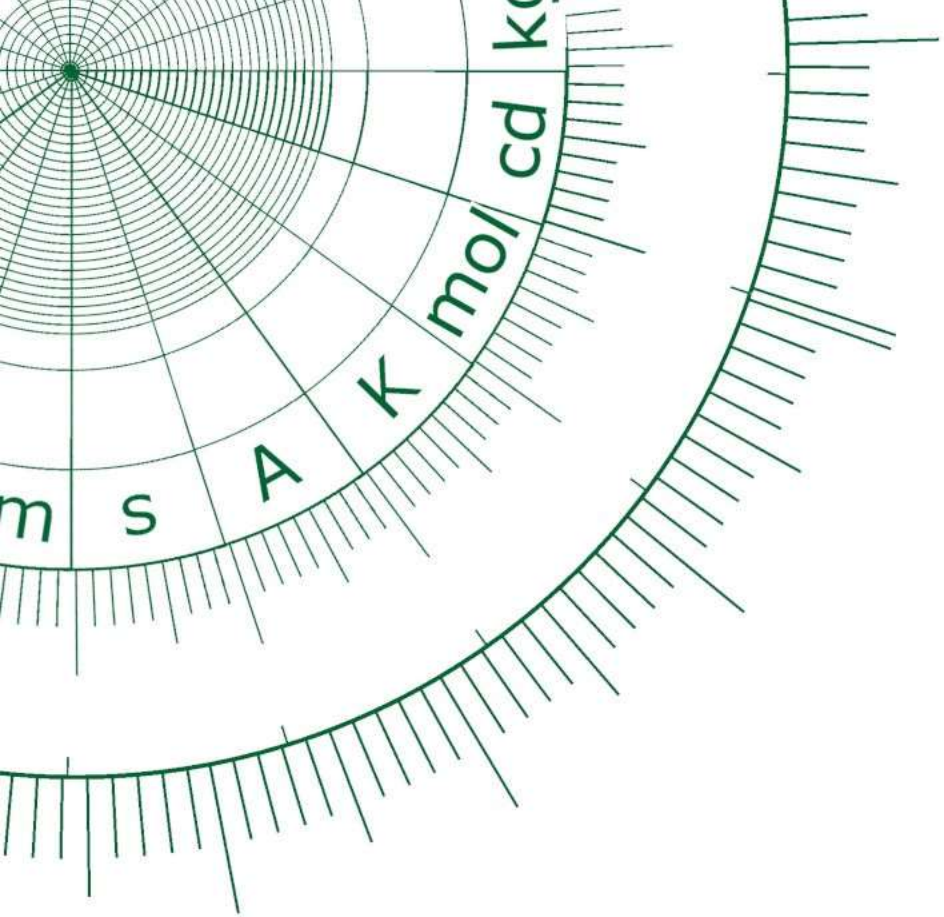
Symbol	Input Quantity (Source of Uncertainty)	Estimated Input Quantity	Estimated Uncertainty	Unit	Probability Distribution (N, R, T, U)	k=	Divisor factor	Standard Uncertainty	Sensitivity Coefficient	Unit	Standard Uncertainty Contribution	Reliability	$1/\nu$	Degrees of freedom calculated	Degrees of Freedom	Remarks
	(X_i)	(x_i)				▼		$U(Xi)$	Ci		$Ui(y)$	%		Calculated	ν	
	▼ Standards and Reference Equipment (Uncorrelated) ▼										nm					
λref	Theoretical value of line source in vacuum	380-1080	5.00E-03	nm	Normal k = 1		1.00	5.00E-03	1.00E+00	1	5.00E-03	100.00	0.00	1.00E+03	infinite	NIST ASD (assume quoted value is standard uncertainty)
n_edlen	Edlen equation uncertainty excl. input uncertainties	1.00023	4.20E-08	1	Normal k = 2		2.00	2.10E-08	-1.00E+03	nm / 1	-2.11E-05	100.00	0.00	1.00E+03	infinite	NIST Eng. Metr. Toolbox (EMT) refractive index
n_temp	Lab Temperature influence on index of refraction	24	2	°C	Triangular √6		2.45	8.16E-01	7.99E-04	nm / °C	6.52E-04	100.00	0.00	1.00E+03	infinite	Sens coef calculated using NIST EMT and spreadsheet
n_humidity	Lab Humidity influence on index of refraction	50	15	%RH	U-Shaped √2		1.41	1.06E+01	1.10E-05	nm / %RH	1.17E-04	100.00	0.00	1.00E+03	infinite	Sens coef calculated using NIST EMT and spreadsheet
n_air pressure	Lab Air Pressure influence on index of refraction	86	2	kPa	Rectangular √3		1.73	1.15E+00	-2.66E-03	nm / kPa	-3.07E-03	100.00	0.00	1.00E+03	infinite	Sens coef calculated using NIST EMT and spreadsheet
Res / Std	Resolution of Standard / Equipment (If applicable)															Not applicable
Data / Std	Type "B" Evaluation Range of the results (Rectangular)															Not applicable
	Type "A" Evaluation Exp Std Dev of the Mean (ESDM)				Normal K = 1		1.00									No of Readings
	▼ Standards and Reference Equipment (Correlated) ▼											NOTE! ONLY CHANGE BLUE CELLS - All OTHER CELLS (WHITE) ARE PROTECTED				
	▼ Unit Under Test / Calibration (Uncorrelated) ▼											NOTE! ONLY CHANGE BLUE CELLS - All OTHER CELLS (WHITE) ARE PROTECTED				
Res / UUT	Resolution of UUT (if applicable) (stepper resolution)	2	1.00E+00	nm	Rectangular √3		1.73	5.77E-01	1.00E+00	1	5.77E-01	100.00	0.00E+00	1.00E+03	infinite	Wavelength interval of UUT is 2 nm.
Data / UUT	Type "B" Evaluation Range of the results (Rectangular)											100.00	0.00E+00			
	Type "A" Evaluation Exp Std Deviation "s"		4.50E-01	nm	Normal K = 1		1.00	4.50E-01	1.00E+00	1	2.01E-01	100.00	2.50E-01		4.00E+00	No of Readings 5
												NOTE! ONLY CHANGE BLUE CELLS - All OTHER CELLS (WHITE) ARE PROTECTED				

About UBM

TOTAL COMBINED UNCERTAINTY			nm				
Best Measurement Capability (Excluding UUT contribution)	Combined Uncertainty (Normal)	▼ Level of Confidence ▼	5.91E-03	V_{eff}	1000.00	infinite	Checked and Approved By:
	Expanded Uncertainty	95,45 % K = 2	**1.18E-02**	k =	0.05	**2.00**	
Uncertainty of Measurement (Including UUT contribution)	Combined Uncertainty (Normal)	▼ Level of Confidence ▼	6.11E-01	V_{eff}	340.87	340.87	
	Expanded Uncertainty	95,45 % K = 2	**1.227**	k =	0.05	**2.01**	



800 nm filter: 0,5 % shift in central wavelength → ~ 1,7 % change in band radiance
690 nm filter: 0,5 % shift in central wavelength → ~ 25 % change in band radiance



nmisa

National Metrology Institute of South Africa

Thank You

We measure what matters