EMRP JRP SIB-05

NewKILO

Developing a practical means of
disseminating the redefined kilogram (June 2012 – May 2015)

Stuart Davidson, NPL, UK

CCM M-e-P Workshop
BIPM, November 2012

Background

This Project will develop a practical means to implement the kilogram redefinition and to facilitate maintenance and traceability following redefinition.

3 key aspects:

- Provide a means of accurately fixing the Planck (and Avogadro) constant with reference to the International Prototype Kilogram (IPK)

Traceability of primary realisations to K

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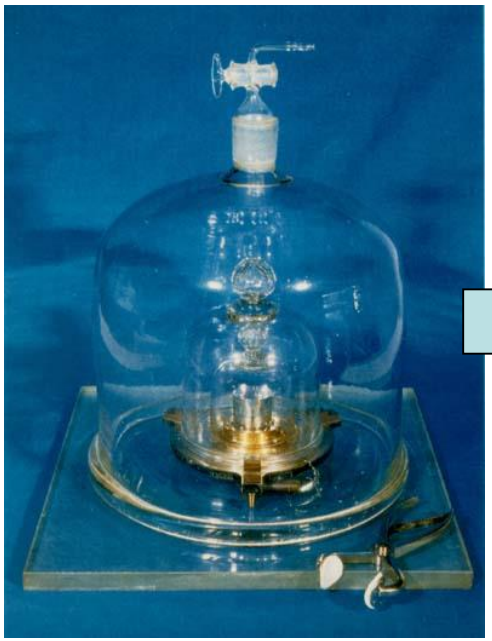
- To enable the accurate determination of the Planck and Avogadro constants with reference to the current mass scale
- Requires air/vacuum transfer, transportation method and watt balance compatible standard masses



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- Allow dissemination of the new realisation at the level of the NMIs should be achieved with uncertainty contributions smaller than the required (relative) uncertainty of the realisation (2×10^{-8})

Dissemination of the scale after redefinition

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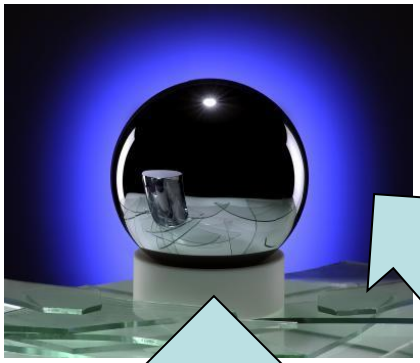
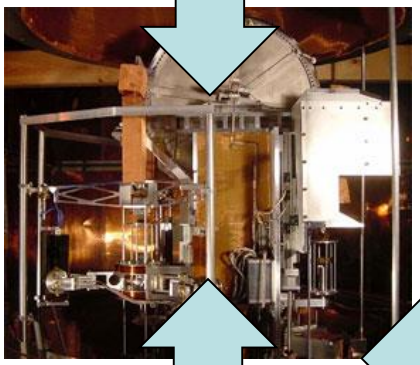
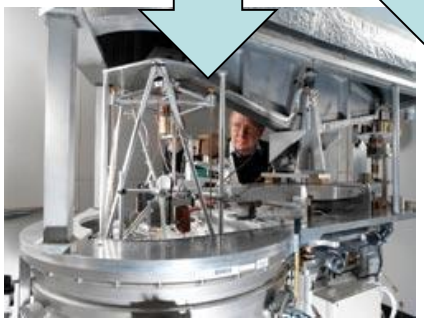
- Comparison of primary realisation experiments
- Dissemination to (national) in air mass scale
- Requires air/vacuum transfer, transportation method and watt balance compatible standard masses
- Minimise the impact of redefinition on current (CMC) uncertainties







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- Provide a means of maintaining the standard between realisations (WB and Avogadro Key Comparison)

Continuity of scale following redefinition

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- A means of maintaining and disseminating the scale between primary realisations with watt balance experiment comparison (every 10 years?)
- Requires
  - (A group of) primary mass standards (of different materials)
  - Means of storage to optimise medium term stability (inc. inert gas and vacuum)
  - Procedures to monitor and compare the relative stability of the group of standards and to disseminate the aggregate value (air/vacuum/inert gas transfer).

Participants

Funded	
JRP-Partners	NPL (JRP-Coordinator) CMI, CNAM, DFM, EJPD, LNE, MHEST MIKES, PTB, SMU, TUBITAK UME
Unfunded	
JRP-Partners	INRIM, NRC
Collaborators	BIPM, KRISS, Sartorius, Mettler-Toledo, Häfner
REG	TU-Ilmenau

Key Project Tasks

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- Develop and evaluate new mass artefacts suitable for use in watt balance experiments and for medium term (5 – 10 year) maintenance (Europe/World Ensemble)
- Provide appropriate procedures and apparatus for the mass transfer between in-vacuum experiments (watt balances and vacuum comparators)
- Evaluate the mass stability of suitably stored mass artefacts and develop the metrological infrastructure for the (medium term) maintenance of the mass unit
- Develop and adapt surface analysis techniques and overlayer models for the accretion of contamination on mass standards (including silicon spheres)
- Develop and validate methods to allow the reproducible cleaning of primary mass standards (UV activated ozone and gas plasma)
- Identify and evaluate the uncertainty components inherent in the *mise-en-pratique* and their propagation through the dissemination chain

WP 1: Development and evaluation of artefacts suitable to provide maintenance and dissemination of a redefined kilogram (Paul-André Meury, LNE)

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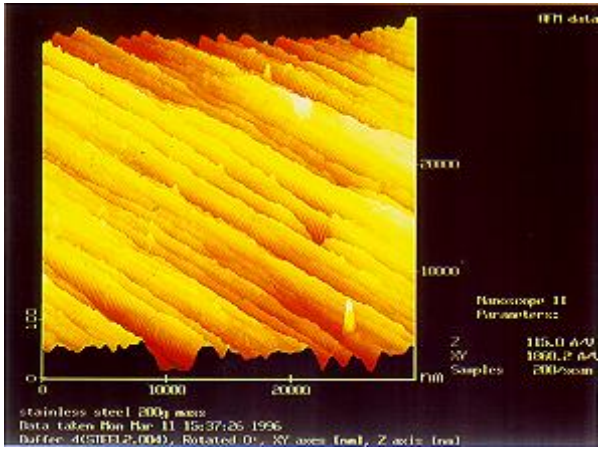
Key deliverables

- Evaluation of material (and coatings) and finishing techniques
- Materials
  - Pt-Ir, SS, Ir, Au alloy, Ni-superalloy, (single crystal) W, Si, plated Cu
- Analysis Techniques

  SEM, AFM, XPS, TDS,
  Instrumented micro-indentation



WP 2: Development and evaluation of procedures and techniques for the mass transfer between vacuum and air (Michael Borys, PTB)

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Key deliverables

- Evaluation of vacuum/inert gas/air transfer procedures
- Measurement of sorption correlation with vacuum pressure (and balance dependence)

- Optimised procedures for the transfer of mass between air and vacuum to minimise the uncertainty due to surface sorption.

WP 3: Surface effects and dynamic changes on the artefact surface between vacuum, air and selected gases (Peter Fuchs, METAS)

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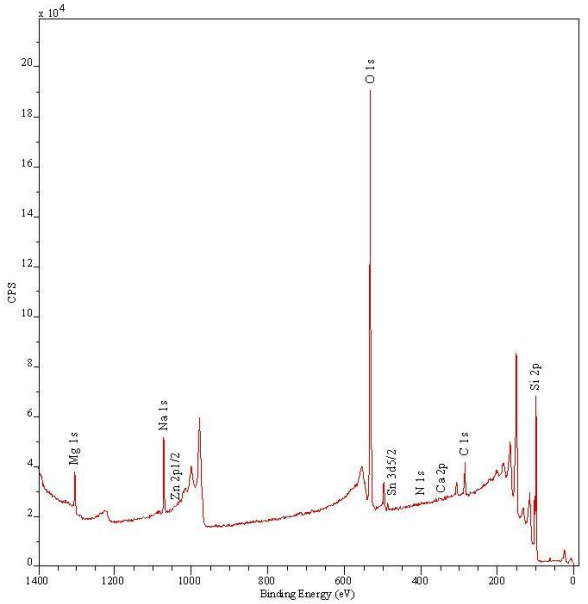
Key deliverables

- Use of complimentary surface analysis techniques to characterise sorption effects (and cleaning and storage results)

- Techniques
  - XPS, XRR, XRF, Elipsometry, RGA, TDS, QCM, AFM, Mirage effect



WP 4: Evaluation of the mass stability of artefacts with a focus on storage, cleaning and transport methods (James Berry, NPL)

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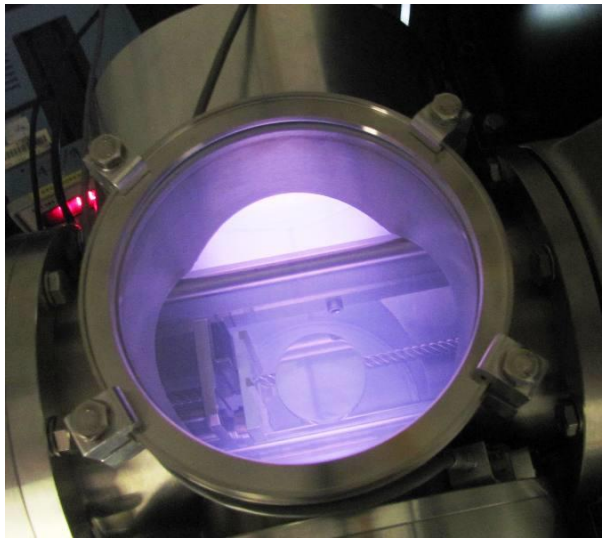
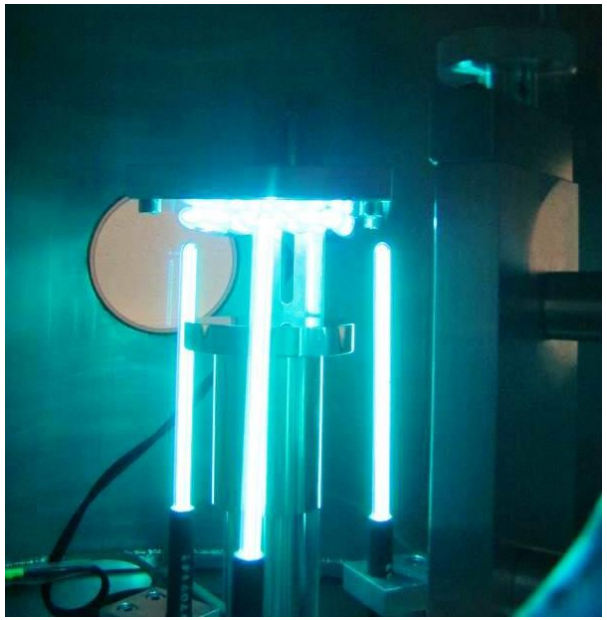
Key deliverables

- Report on design for Storage and transfer apparatus for primary mass standards
- Evaluation and optimisation of cleaning techniques for primary mass standards
- Protocol for medium-term (5-10 years) storage of mass standards and transfer between vacuum apparatus





WP 5: Identification and evaluation of the uncertainty components inherent in the *mise-en-pratique* and in their propagation through the dissemination chain (Lars Nielsen, DFM)

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Key deliverables

- Model for air-vacuum mass change for artefact transfer
- Model for mass change during storage and for transportation and cleaning
- Evaluation of uncertainty of the unit of mass derived from a pool of artefacts (calibrated against primary realisations)

Progress

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WP1: Agreement on sample requirements

Au alloy, SS and Pt-Ir samples available (BIPM)

Samples of W (single and poly) produced (NRC)

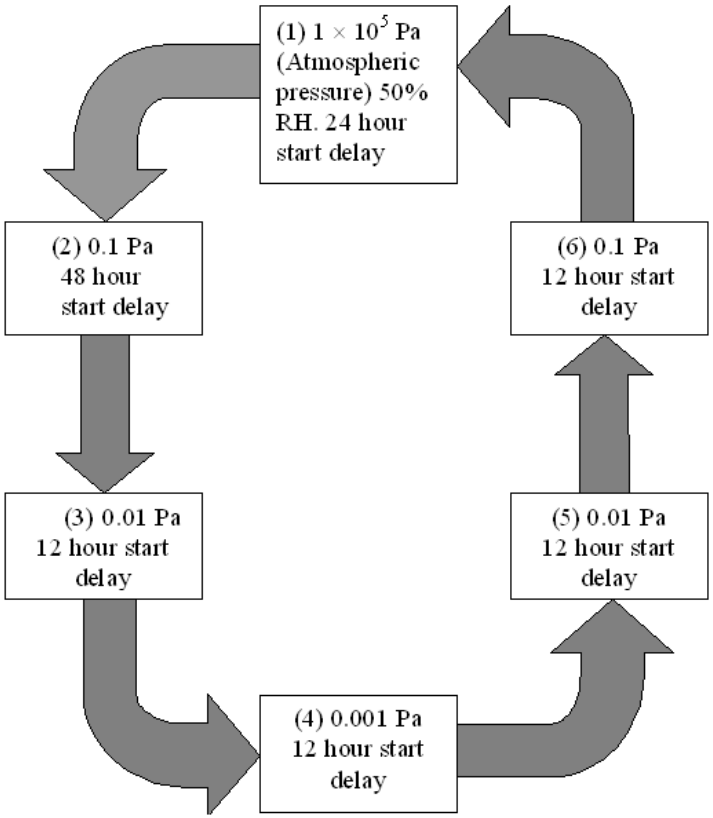
Cu electroplated with gold and rhodium (Häfner)

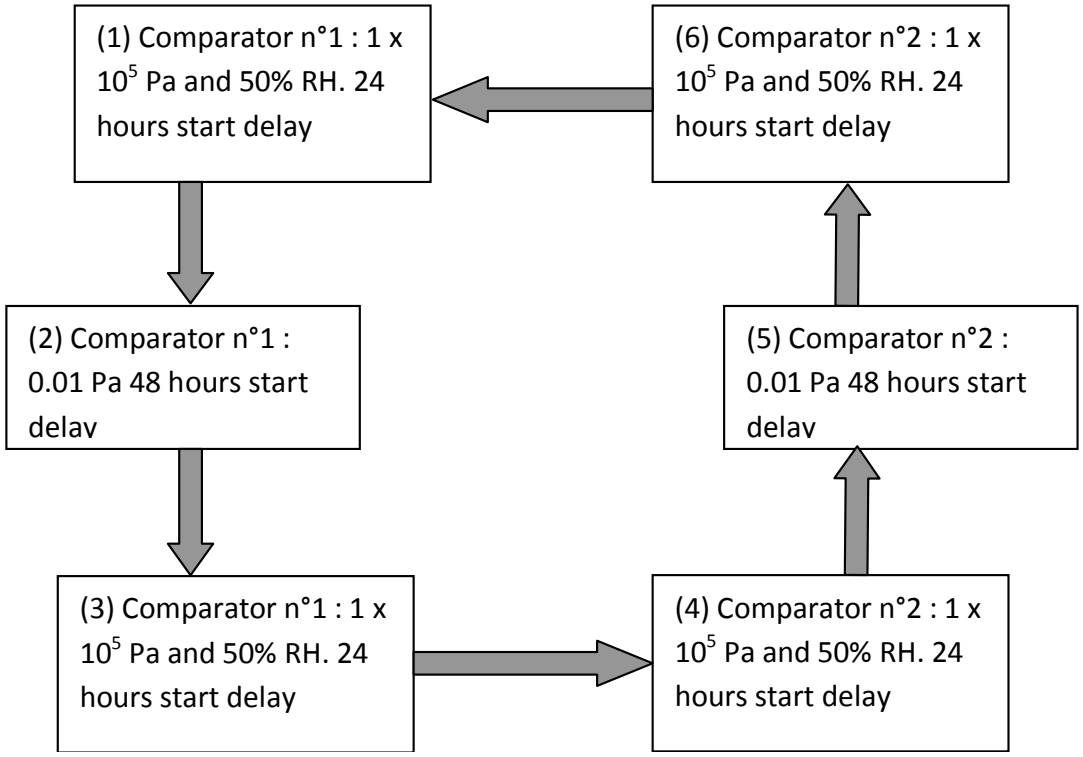
Si and Ir samples prepared for polishing

WP2: Surface samples for sorption measurements produced

Standards and protocol for air-vacuum transfer evaluation completed (pressure and balance dependence)

WP3: Protocol for analysis methods and transfer processes


(1) 1 × 10^5 Pa (Atmospheric pressure) 50% RH. 24 hour start delay
(2) 0.1 Pa 48 hour start delay
(3) 0.01 Pa 12 hour start delay
(4) 0.001 Pa 12 hour start delay
(5) 0.01 Pa 12 hour start delay
(6) 0.1 Pa 12 hour start delay


(1) Comparator n°1 : 1 x 10^5 Pa and 50% RH. 24 hours start delay
(2) Comparator n°1 : 0.01 Pa 48 hours start delav
(3) Comparator n°1 : 1 x 10^5 Pa and 50% RH. 24 hours start delay
(4) Comparator n°2 : 1 x 10^5 Pa and 50% RH. 24 hours start delay
(5) Comparator n°2 : 0.01 Pa 48 hours start delav
(6) Comparator n°2 : 1 x 10^5 Pa and 50% RH. 24 hours start delay

AMBIENT AIR /GAZ	**Air/gas**	**ellipsometry**	**QCM**	**Mirage?**			**QCM**		**CA**	**AFM**			**AFM**				
		NPL	**NPL**	**CNAM**			**EJPD**		**EJPD**	**CMI**			**MIKES**				
	PtIr	x	x				x		x				x				
	AuPt	x	x				x		x	x							
	Ir	x	x				x		x				x				
	SS									x			x				
	Si	x	x							x							
	W	x	x				x		x				x				
	Ni alloy	x	x							x							
	Au (ep)						x		x	x			x				
	Rh (ep)						x		x	x			x				
TRANSFER	**Transition**		**QCM**	**Mirage**	**TDS**	**TDS?**	**QCM**										
			NPL	**CNAM**	**CNAM**	**CMI**	**EJPD**										
	PtIr		x	x	x		x										
	AuPt		x	x			x										
	Ir		x	x	x		x										
	SS			**	**	x											
	Si		x	x		x											
	W		x				x										
	Ni alloy		x														
	Au (ep)						x										
	Rh (ep)						x										
VACUUM	**Vacuum**	**XPS**	**QCM**	**Mirage**	**TDS**	**TDS**	**QCM**		**XPS**	**XPS**	**XRR**	**XRF**	**XPS**				
		NPL	**NPL**	**CNAM***	**CNAM***	**CMI**	**EJPD**		**EJPD**	**CMI**	**PTB**	**PTB**	**TUBITAK**				
	PtIr	x	x	x	x		x		x		x						
	AuPt	x	x	x			x		x	x		x					
	Ir	x	x	x	x		x		x		x	x					
	SS			**	**	x				x			x				
	Si	x	x	x		x				x	x	x					
	W	x	x				x		x		x	x	x				
	Ni alloy	x	x							x							
	Au (ep)						x		x	x			x				
	Rh (ep)						x		x	x			x				

Progress (cont.)

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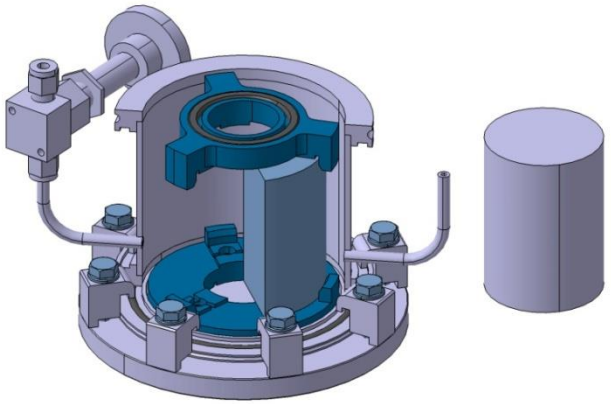
WP4: Draft report detailing requirements of NMIs for storage and transfer of artefacts completed.

Common approach to storage/transfer vessels agreed
Examination of materials suitable for mass storage underway

WP5: Extant data from sorption comparison being analysed

WP6: Stakeholder/steering committee established

Website www.newkilo.sk set up.



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Thank You For Your Attention