

CCM WGG chairman Report to CCM-2013

June 2011 – February 2013

L.Vitushkin, VNIIM, Russia

BIPM

21 February 2013

Terms of Reference of WGG

The version of 2003

(currently on website page of CCM WGG)

To draw up appropriate protocols for the comparison of absolute gravimeters;

To organize periodic comparisons of absolute and relative gravimeters and related workshops;

To draw up procedures for the evaluation of the results of these comparisons, including standardized procedures for data processing;

To make proposals for ongoing work on gravimetry at the BIPM; and

To advise the Consultative Committee, and through it the CIPM, on matters related to absolute gravimetry.

Discussion by correspondence on the ToR of WGG:

The modification of the ToR of 2003 was initiated by WGG.

The first draft was discussed at the WGG-2012 meeting and by correspondence after the meeting.

The second modified version was distributed among WGG members on 29 October 2012.

During the discussion on the ToR the WGG also tried to estimate itself the efficiency of its work and its necessity for metrology community and for the stakeholders of absolute gravimeters.

The draft of a new version 2-4 of 29 January 2013
Terms of Reference of CCM WGG

- To advise the CCM on issues related to gravimetry,
- To prepare guidelines, recommendations and procedures necessary for the organization of International Comparisons of Absolute Gravimeters (ICAG) as Key or Pilot Studies,
- To recommend to the CCM gravimetric sites and pilot laboratories for ICAGs and to offer advice in these matters to RMOs carrying out Regional Comparisons of Absolute Gravimeters (RCAGs),
- To coordinate WGG recommendations on site selection with Commission 2 “Gravity field” of the International Association of Geodesy (IAG), to further the establishment of a new International System of Absolute Gravity Stations,
- To provide guidance to pilot laboratories in preparation of the technical protocol of ICAGs and RCAGs,
- To assist the CCEM WG on Electrical Methods to Monitor the Stability of the Kilogram (WGKG) with issues related to absolute gravity measurements in experiments on realization of electronic kilogram,
- To identify, in cooperation with stakeholders, the needs for metrology in gravimetry, and to encourage and advise the NMIs and DIs to offer the CMC in gravimetry and to provide guidance to RMOs in evaluating them,
- To provide working documents to help to evaluate uncertainty in gravimetry,
- To exchange information and research results in absolute gravity measurement and instrumentation, and on related metrological problems.

Membership in the WGG and its operation are regulated according to Chapter 6 of CIPM-D-01

CCM WGG members (28 May 2012)

	NMI/DI	Country	Representative	CMC
1	VNIM	Russian Federation	Leonid Vitushkin Chairman	NO
2	METAS	Switzerland	Henri Baumann	YES
3	BGI International organization	France	Sylvain Bonvalot	NO
4	NIST	USA	James Faller	NO
5	Luxemburg University	Luxemburg	Olivier Francis (individual expert)	NO
6	INRiM	Italy	Alessandro Germak	YES
7	UME TÜBITAK	Turkey	Baki Karaböce	NO
8	VNIIM,	Russian Federation	Evgeny Krivtsov	NO
9	IGC (DI)	Poland	Jan Krynski	NO
10	NRC	Canada	Jacques Liard	NO
11	FGI (DI)	Finland	Jaakko Mäkinen	YES
12	Geodetic Observatory Pecny (DI)	Czech Republic	Vojtech Palinkas	NO
13	NMIJ	Japan	Shigeki Mizushima	NO
14	LNE-SYRTE	France	Franck Pereira Dos Santos	NO
15	BIPM		Lennart Robertsson	NO
16	NPL	UK	Ian Robinson	NO
17	BEV	Austria	Diethard Ruess	YES
18	Royal Observatory of Belgium	Belgium	Michel Van Camp (individual expert)	NO
19	PTB	Germany	Herbert Wilmes (representative of PTB for gravimetry)	NO
20	NIM	China	Wu Shuqing	NO

A new candidate for WGG membership:
Dr. In-Mook CHOI (KRISS)

February 4, 2013

Dr. Leonid F. Vitushkin
Chairman of the CCM-WGG
Head of laboratory of gravimetry and
advanced projects
All-Russian D.I. Mendeleev Research Institute
for Metrology (VNIIM), Moskovesky pr., 19
190005, St Petersburg,
Russia

Dear Dr. Vitushkin:

LETTER OF RECOMMENDATION

It is my great pleasure to submit a nomination of Dr. In-Mook CHOI, principal researcher of KRISS as a member of Consultative Committee for Mass and Related Quantities, Working Group on Gravimetry (CCM-WGG).

Dr. In-Mook CHOI has been intensively involved in absolute gravimetry since 2006. While he was working at NPL as a guest researcher in 2006, he began to work on the absolute gravimetry. Since he came back to KRISS in 2007, he has been establishing national gravity standard in Korea as a pioneer. He is also actively working in the watt balance project where the absolute gravity measurement plays a key role.

In general, Dr. CHOI has shown outstanding ability and excellent performance in his work and sincere attitude in every aspect of his life. So, I strongly believe that his work will contribute to the development of CCM-WGG and give a positive influence on the global metrology community.

With pleasure, I would like to recommend him as CCM-WGG member and please kindly find the enclosed nomination of Dr. CHOI.
Your acceptance would be much appreciated. Thank you.

Sincerely yours,



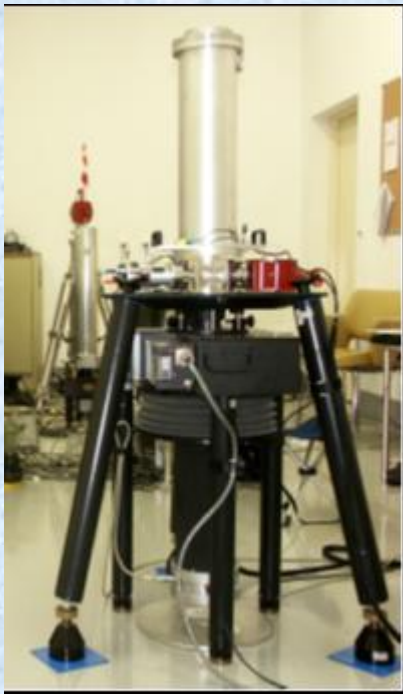
Seung Nam Park, Ph. D. (snpark@kriss.re.kr)
Director, Div. of Physical Metrology
Korea Research Institute of Standards and Science (KRISS)

The end users of confident and traceable absolute gravity measurements are the NMIs (for watt-balance type experiments, for the calibration of absolute gravimeters and often for in-the-field measurements), DIs, International Union of Geodesy and Geophysics, International Association of Geodesy, geodetic, geophysics, geological and other services for the engineering geology, hydrology, for the geological exploration, for the monitoring of mineral reserves including the hydrocarbons and water, for the support (calibrations) of international, national and local gravimetry networks.

The absolute gravimetry is the part of Global Geodetic Observation System and of Global Geodynamic Project.

Terrestrial absolute gravimetry is necessary for the development and improvement of the global and local models of the gravity field of the Earth which are necessary for the Global Navigations Satellite Systems GPS, GLONASS, Galileo, etc.

**Measuring techniques in absolute gravimetry currently in use
and the trends in its development**



FG5-1##



FG5-2## and A10



FGL

The main part of absolute gravimeters currently in the use over the world are the commercial ABGs produced by one company.

59 gravimeters of the type FG5 and 31 A-10 were fabricated to 2012.



NIM-II, NIM, China



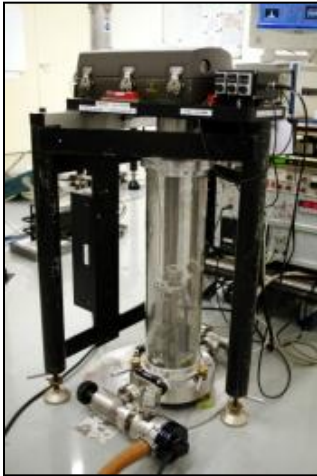
VNIIM-ABG-1 (Russia)



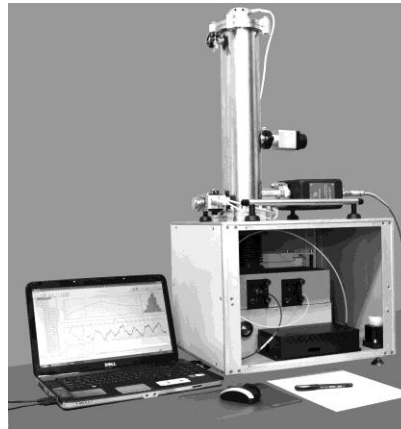
FGC-1 (USA)



**A. Araya, JGSJ, 2010,
v 56, n1, p 1-12 (Japan)**



INRiM-2 (Italy)



**Mini-GABL (Russia)
Proc. TGSMM-2010**

Gravimeters (with the macroscopic test bodies) under development and improvement.

小型对称式绝对重力仪



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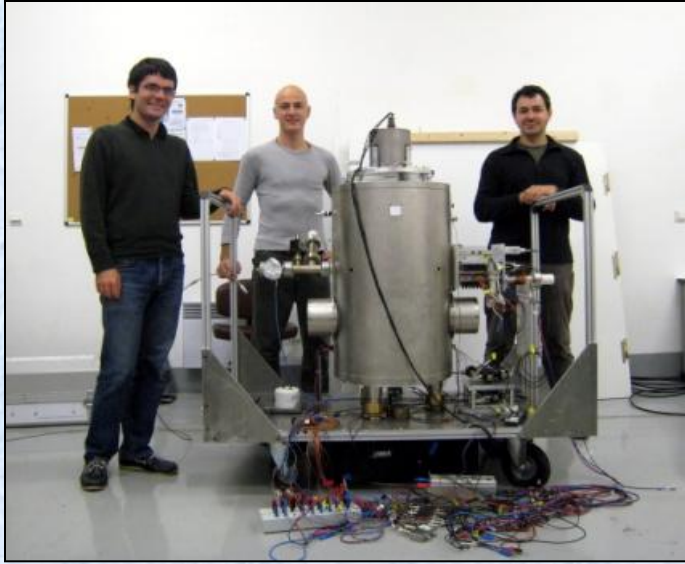
高精度绝对重力仪是近20年发展起来的新技术，是地学研究必备的精密仪器、也是国防必须的尖端设备，目前只有美国等少数国家能够生产。美国将高精度绝对重力仪用于火星探测、核潜艇导航、导弹制导等领域。该技术对中国的出口受美国政府的严格限制，因此，自主研发高精度绝对重力仪，对我国国防建设和地学研究有重要意义。

由鹤壁市仪表厂有限责任公司与郭有光教授等合作研制的“小型对称式绝对重力仪”已于2005年9月完成了本体的设计与制造。实验数据表明，该仪器已达到了数十微伽的精度水平。

新一代“小型对称式绝对重力仪”在结构上有五个创新特点：一是将下落法改进为上抛下落对称法以增加测量行程、并降低对真空度的要求，二是将超长弹簧改进为长周期地震摆以加强仪器的整体性，三是将双分光镜改进为单分光镜以简化光路，四是采用电磁抛射技术比过真空传动伺服下落技术简单可靠，五是采用高速数采板取代专用测时设备。技术创新使得“小型对称式绝对重力仪”的整机体积大为缩小，提高仪器的可靠性和灵活性，易于产业化。

GA-1, China

Cold atom gravimetry: from “transportable” to “compact”



gravimeter



optical table



gravimeter and electronics at the site

**Cold atom gravimeter , LNE-SYRTE, France
in ICAG-2009**



μQUANS

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2012-10-24:

Muquans and its AQG won the top prize at the Vitrine de l'innovation awards >>

2012-05-24:

Muquans wins the Innovation Award at Innovaday 2012 >>

2011-12-10:

Selection of projects MIGA and RESIF-CORE at the national call EQUIPEX 2011 >>

2011-12-26:

Muquans obtains the award 'JEI' from the

μQuans proposes a new generation of sensors based on a unique and patented technology, involving the manipulation of neutral atoms. We provide our customers with optimized solutions for operability. We have developed a disruptive technological approach, which allows us to offer at the same time quantum precision measurements, along with a real turn-key operation and simple maintenance.

Our current product portfolio includes:

- An **absolute quantum gravimeter** capable of measuring gravity with a relative accuracy of 10^{-9} , dedicated to various geophysics applications.
- An **atomic clock** (under development), which provides a time reference signal offering relative stability and accuracy close

- An **absolute quantum gravimeter** capable of measuring gravity with a relative accuracy of 10^{-9} , dedicated to various geophysics applications.



Cold atom gravimeters are in the process of development also in China, Germany and USA.

The BIPM key comparison database



Refine your search

CMC AREA

[CMCs General Physics \(1\)](#)

PHYSICS

[Torque, Viscosity, Hardness and Gravity \(1\)](#)

GEOGRAPHIC LOCATION

[EURAMET \(1\)](#)
[Finland \(1\)](#)

Result of the search

Your query 'acceleration of free fall' produced 1 result

[New search](#)**Finland, FGI (Finnish Geodetic Institute)**[Complete CMCs in Mass and related quantities for Finland \(.PDF file\)](#)Acceleration of free fall. On (stable) site, **9.75 m/s² to 9.85 m/s²**Absolute expanded uncertainty ($k = 2$, level of confidence 95%) in m/s²: **8.0E-08**

Free fall experiment

Ambient temperature: 21 °C ± 8 °C

Approved on 03 January 2007

Austria, BEV (Bundesamt für Eich- und Vermessungswesen)[Complete CMCs in Mass and related quantities for Austria \(.PDF file\)](#)Gravitational acceleration. On (stable) site, **9.75 m/s² to 9.85 m/s²**Absolute expanded uncertainty ($k = 2$, level of confidence 95%) in m/s²: **1.0E-07**

Absolute measurement

Ambient temperature: (21 ± 5) °C

Italy, INRIM (Istituto Nazionale di Ricerca Metrologica)[Complete CMCs in Mass and related quantities for Italy \(.PDF file\)](#)Gravitational acceleration. On (stable) site, **9.75 m/s² to 9.85 m/s²**Absolute expanded uncertainty ($k = 2$, level of confidence 95%) in m/s²: **1.5E-07**

Absolute measurement

Ambient temperature: 23 °C ± 10 °C

Approved on 03 January 2007

Switzerland, METAS (Federal Office of Metrology)[Complete CMCs in Mass and related quantities for Switzerland \(.PDF file\)](#)Gravitational acceleration. On (stable) site, **9.75 m/s² to 9.85 m/s²**Absolute expanded uncertainty ($k = 2$, level of confidence 95%) in m/s²: **8.0E-08**

Absolute measurement

Ambient temperature: (20 ± 5) °C

Approved on 02 July 2008

CMC in gravimetry

Calibration and Measurement Capabilities (CMC) of National Metrology Institutes on the BIPM KCDB:

Austria (BEV), uncertainty 10 μGal

Finland (FGI), uncertainty 8 μGal

Italy (INRiM), uncertainty 15 μGal

Switzerland (METAS), uncertainty 8 μGal

Four NMIs-DIs informed on their plans to submit the CMC in the field of the measurement of free-fall acceleration:


NIM (China)

KRISS (Korea)

Geodetic Observatory Pecný (Czech Republic) –Designated
Institute

UME TÜBITAK (Turkey)

Comparisons of absolute gravimeters on KCDB

The BIPM key comparison database 

Refine your search

METROLOGY AREA

- Mass (5)

TYPE

- Key comparisons (3)
- Supplementary comparisons (2)

STATUS

- Approved for equivalence (2)
- Planned (2)
- Approved and published (1)

ORGANISATIONS

- EURAMET (formerly EUROMET) (2)
- CCM (2)
- APMP (1)

Result of the search

Your query 'free fall acceleration' produced 5 results [New search](#)

CCM.G- K1	Free-fall acceleration 2009
Comparison type, Field	Key comparison in Mass, Gravity Free-fall acceleration
Status	Approved for equivalence, Results available
EURAMET.M.G- S1	Free-fall acceleration 2008
Comparison type, Field	Supplementary comparison in Mass, Gravity
Status	Approved and published
EURAMET.M.G- K1	Free-fall acceleration 2011
Comparison type, Field	Key comparison in Mass, Gravity
Status	Approved for equivalence, Results available
APMP.M.G- S1	Free-fall acceleration 2012
Comparison type, Field	Supplementary comparison in Mass, Gravity
Status	Planned
CCM.G- K2	Free-fall acceleration 2013
Comparison type, Field	Key comparison in Mass, Gravity Free-fall acceleration
Status	Planned

ICAG-2009, 21 absolute gravimeters from 17 countries

11 participants in **KC CCM.G-K1**, 10 participants in **Pilot Study**

ICAG-2013, 26 absolute gravimeters from 19 countries

10 participants in **KC CCM.G-K2** and 16 participants in **Pilot Study**

Specificity of comparisons of absolute gravimeters

Currently the ICAGs and RCAGs consist of two parts:

Key Comparison and Pilot Study.

A Pilot Study part is provided to open ICAG to those participants who would be excluded from participation in a KC part because they are not from NMIs or DIs.

This structure of comparisons is not a correct one and it should be avoided after some transition period before a sufficient metrological service (calibrations) of absolute gravimeters will be established.

Currently 1) there are not enough DIs and NMIs with the capabilities in calibration of absolute gravimeters and 2) the declared uncertainties of existing CMCs are bigger than that which can be obtained in comparisons.

Scientific North-American Comparison of Absolute Gravimeters (NACAG-2010) in Table Mountain Geophysical Observatory (Longmont, Colorado) in October 2010.

Eight absolute gravimeters FG5 and one A10.

Results are published in J.Geod., 2012, pp 591-596, D. Schmerge et al.

Table 1 Participants in NACAG-2010 and the combined instrumental and site uncertainties (u) of each gravimeter as declared by the owners and operators

Country	Institution	Gravimeter	$u/\mu\text{Gal}$
USA	United States Geological Survey	A10-008	10.0
USA	National Oceanic and Atmospheric Administration	FG5-102	2.4
Canada	National Research Council Canada	FG5-105	2.7
Canada	Geological Survey of Canada/Natural Resources Canada	FG5-106	2.7
USA	National Science Foundation/Micro-g Lacoste, Inc.	FG5-111	2.1
USA	National Institute of Standards and Technology	FG5-204	2.7
USA	National Geospatial-Intelligence Agency	FG5-205	2.4
Canada	Natural Resources Canada	FG5-236	2.7
Germany/USA	Federal Agency of Cartography and Geodesy (BKG)/Micro-g LaCoste, Inc.	FG5-301	2.4

Results of the first North American comparison of absolute gravimeters, NACAG-2010

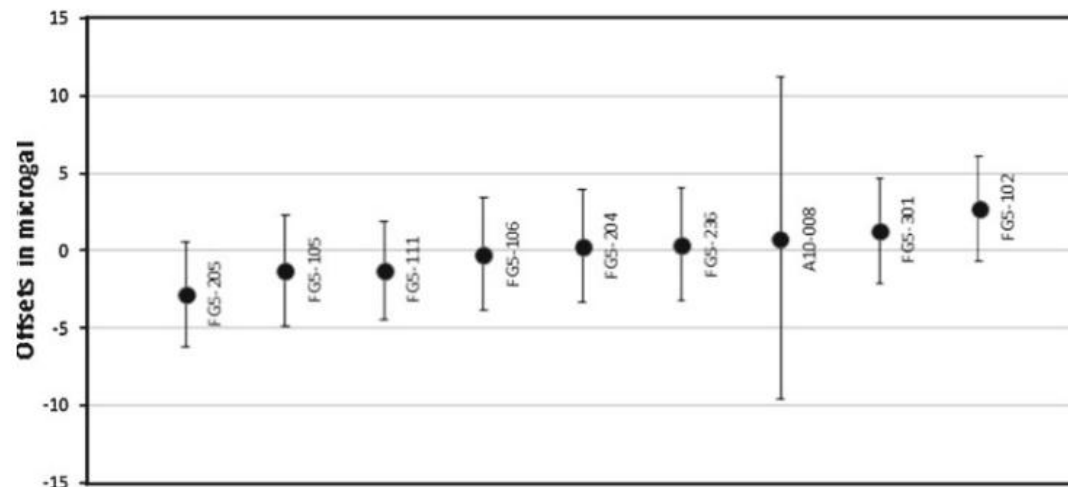


Fig. 3 Offsets for each instrument. The uncertainty has been multiplied by 2 (equivalent to 2 sigma)

The second North-American Comparison of Absolute Gravimeters (**NACAG-2013**) in Table Mountain Geophysical Observatory in October 2013 is in the process of preparation.

Would it be possible to organize it as the SIM RCAG ?

More ICAGs and RCAGs:

- The **APMP RCAG** will be organized in Changping Campus (NIM) in 2015.
- The **ICAG-2017** (WGG recommends to CCM the Changping Campus of NIM to host the comparison and NIM as a Pilot laboratory).
- The **EURAMET** comparison between 2013 and 2017 will be appropriate.

The link between the CIPM KC of 2009 and EURAMET comparison in 2011 was established.

The WGG has had two meetings after the CCM-2011.

- the meeting at UME TÜBITAK (Istanbul, Turkey) on 29-30 May 2012 (with 11 WGG members)

and

- the meeting at BIPM on 18 February 2013 (with 18 WGG members).

The agenda of the meeting in Istanbul has included the issues related to the selection of the site for ICAG-2017 and the discussion on the scientific issues related to the technical protocol for the comparisons of absolute gravimeters .

Actions after the WGG meeting in Istanbul (29-30 May 2012)

- Preparation, discussion and adoption of the “Guide to evaluation of the sites for comparison of absolute gravimeters” (document CCMWGG-12-12 in open access).
- Exchange of opinions concerning the realization of the procedure for the selection of the site for ICAG-2017 and the selection by the vote one of two proposed sites. One site was proposed by LNE (France) and the second one was proposed by NIM (China).
- Request for the official applications from **LNE** and **NIM** and the evaluation of these applications within WGG have been analyzed. Conclusion – both sites fulfil the requirements to the sites for comparison.
- **Additional arguments have been taken into account:**
 - Eight ICAGs and two EURAMET RCAGs were in Europe. From 1994 both geodesy and metrology communities (Metrologia, vol. 32, no. 3, 1994) wanted to organize the comparisons on continental scale.
 - Letter of APMP President with the request to organize the comparison in China.
- The vote was organized (by correspondence) for the selection of the site to be recommended to CCM-2013. The results of the vote are: **15 for NIM, 3 for LNE, 1 abstention** (from 19 voting members).

The first draft of the document “Guidelines for preparation of WGG recommendations to CCM of the sites for ICAGs” was prepared and distributed among WGG members on 8 December 2012.

This document is determined as a complementary document to CIPM MRA-D-05 which clarifies a specific character of organization of ICAGs.

The WGG meeting on 19 February 2013 has formulated the following outcomes which determine a future activities of WGG:

- **To create a focus group for further development of “Guidelines for preparation of WGG recommendations to CCM on the sites and pilot laboratory for International Comparisons of Absolute Gravimeters” document. The focus group will consist of eight members with Jaakko Mäkinen acting as a moderator of the group. Document will be ready by the end of 2013.**
- **To submit comments related to the Technical Protocol of the comparison by the end of July of 2013. Pilot laboratory, METAS, will submit agreed technical protocol by the end of September 2013.**
- **To propose to CCM for approval NIM (China) as the pilot laboratory and Changping Campus as the host site for ICAG 2017.**
- **The chairman of Joint Working Group 2.2 “Absolute gravimetry and absolute gravity reference system” of IAG informed on the planned establishment of a new Absolute Gravity Reference System. CCM WGG propose to reinforce the cooperation with IAG in a more official way based on agreement or Memorandum of Understanding.**

- **CCM WGG will work on the elaboration of a document for the organization of future comparisons in gravimetry and the dissemination of their results. This work will be carried out in cooperation with the geodetic and geophysics communities.**
- **To create a focus group for the preparation of guidelines for evaluation of measurement uncertainty in absolute gravity measurements with Leonid Vitushkin as the moderator.**
- **To continue the studies of the sources of systematic uncertainties and corrections in absolute gravity measurements as, for the example, the frequency noise of the laser, finite speed of the light, gradients of geomagnetic field, etc.**
- **CCM WGG recommends accepting Dr. In-Mook Choi (KRISS, Korea) as a CCM WGG member.**
- **To accept the offer of NIM to host the next CCM WGG meeting in Beijing, China. A decision on the date of the next meeting will be made later.**
- **CCM WGG considers that its activity is necessary and efficient for both the metrology and the geodetic-geophysics communities.**

Thank you for your attention !