Time, Frequency and Gravimetry Section

Work programme 2013-2016

Elisa Felicitas Arias

18th meeting of the CCTF

BIPM, Sèvres, 4-5 June 2009

- Achievements in last 10 years
- Work - programme 2009 – 2012 is running,
  - Modified after prioritization of programmes at BIPM after the CGPM in 2007;
- CIPM workshop in November 2008 for discussing on the future of the BIPM in preparation of the CGPM 2011,
  - My vision, inspired in the evolving needs of NMIs, of the activities at BIPM and in the section for 2013 – 2016, including staff evolution in the section to deliver to NMIs the proposed work programme.
- TFG programme of work for 2013-2016, v0.1, including whet is under discussion at the BIPM today

Achievements in last ten years (1)

- Timely production of UTC/TAI/TT and CCTF-K001.UTC
- Increasing metrological quality of time scales
  - Frequency stability 0.6×10^{-15} (1998) → 0.4×10^{-15} (2008)
  - Frequency accuracy 0.4×10^{-14} (1998) → 0.5×10^{-15} (2008)
- Improved uncertainty of clock comparison through
  - Development of new methods (all-in-view GPS satellites)
  - Adapting the software to data from sophisticated equipment in laboratories
  - Measures of relative delays of time transfer equipment

Time links and uncertainties

GPS common-views

dual-frequency

TW improved

u_A ~ 1 – 4 ns
u_B 1 – 7 ns

GPS all in view

dual-frequency

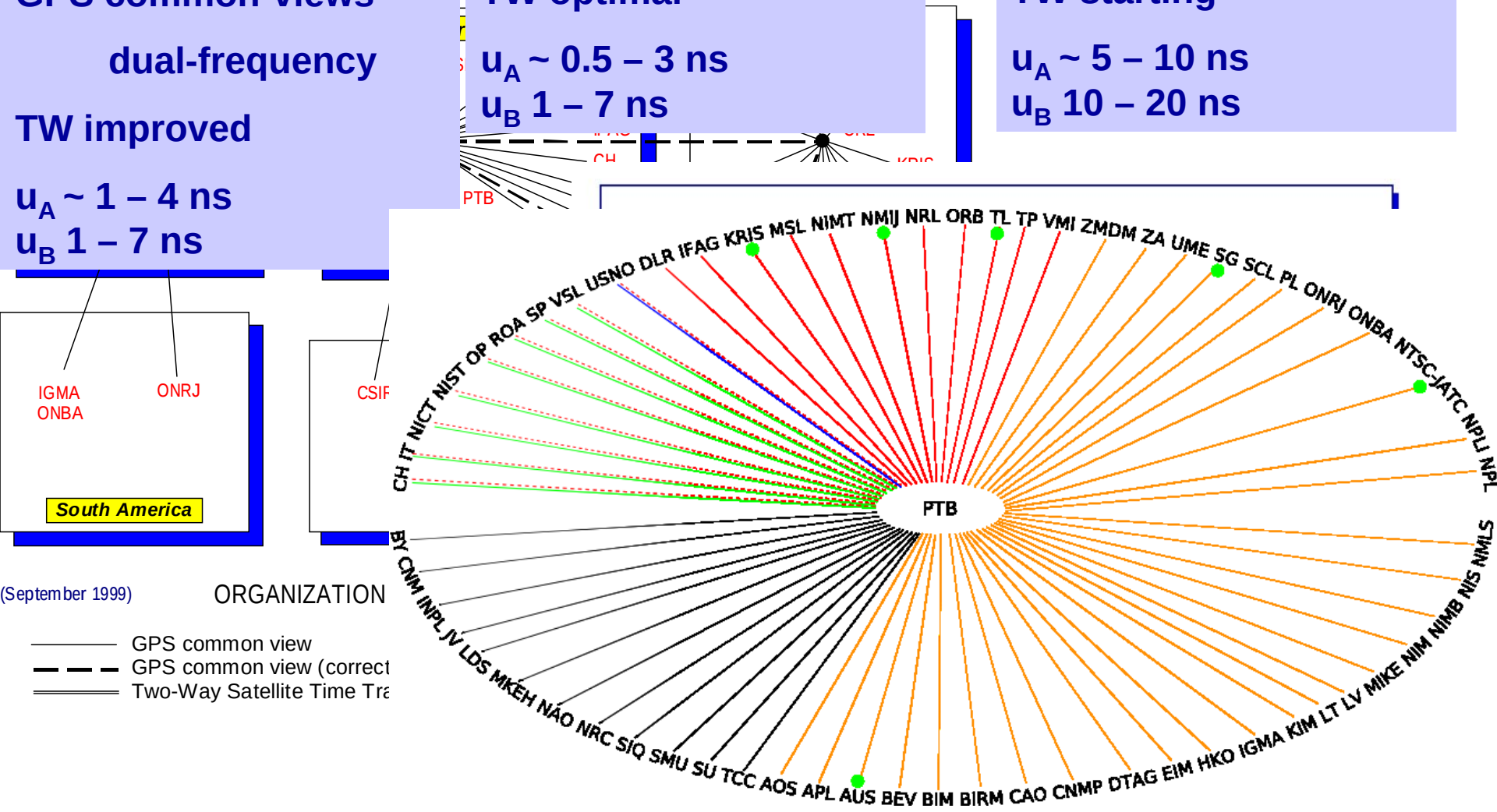
TW optimal

u_A ~ 0.5 – 3 ns
u_B 1 – 7 ns

GPS common-views

TW starting

u_A ~ 5 – 10 ns
u_B 10 – 20 ns



Achievements in last ten years (2)

- Adopting strategies for a better use of primary frequency standards
  - Frequency steering procedure
  - Refined calculation of uncertainties

- Providing to NMIs the most complete set of information on time scales through the internet

Achievements in last ten years (3)

- Increasing our visibility through a policy of listening the requests from NMIs and other participating laboratories
  - Advising on equipment, laboratory organization
  - Developing software for application in laboratories
  - Receiving visitors from NMIs
  - Visiting NMIs
  - Keeping contact with RMOs
- Enhancing the interest of contributing to UTC/TAI and participating in key comparisons in t&f
    - To obtain traceability to the SI unit, UTC
    - To participate to the CIPM MRA through declaration of CMCs

1998

Part. nations: 31

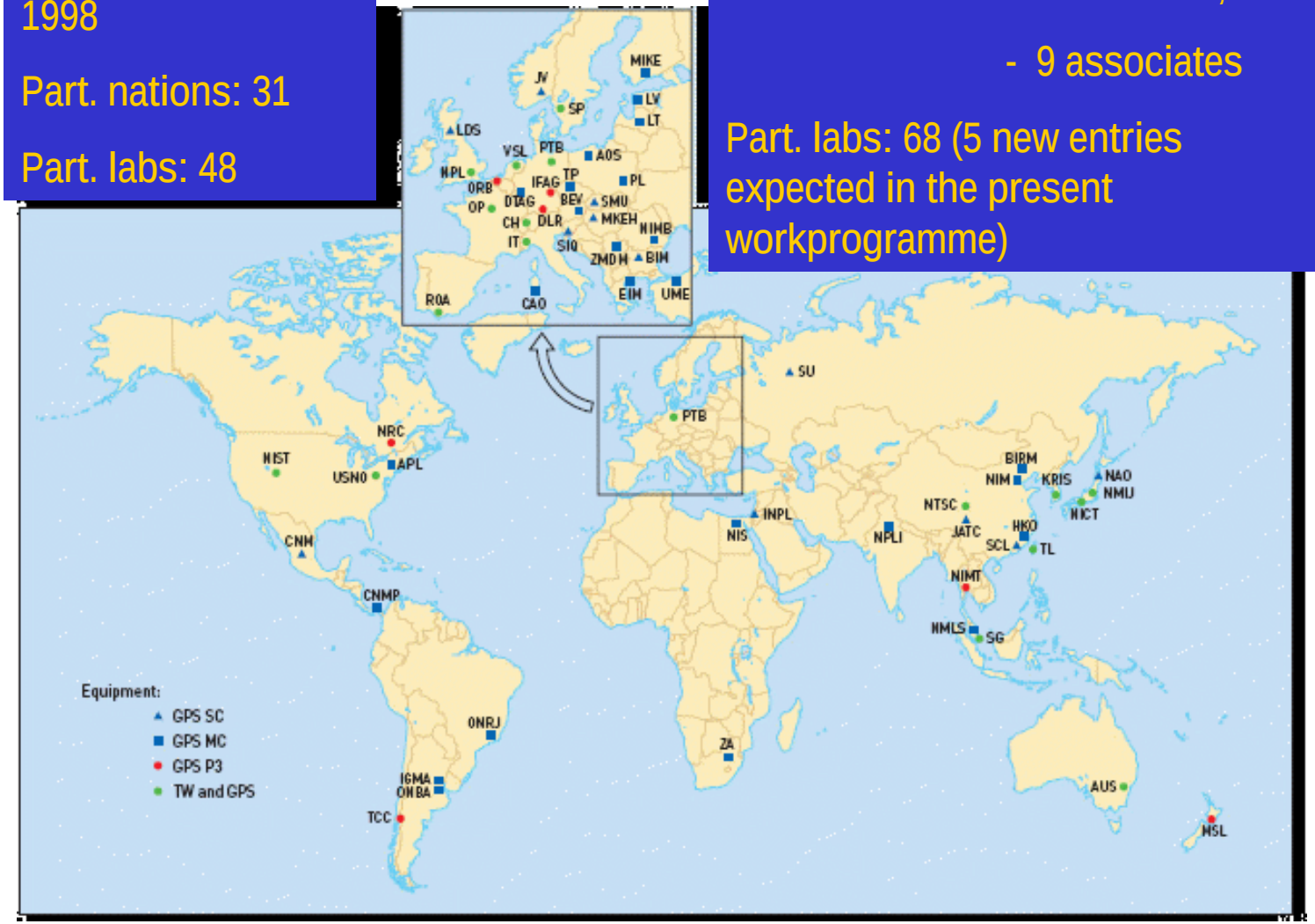
Part. labs: 48

2009

Part. nations: 51 - 42 M.States,

- 9 associates

Part. labs: 68 (5 new entries expected in the present workprogramme)



Achievements in last ten years (6)

- Well established programme of scientific international coordination
- Between NMIs for key comparisons and calibrations
- With international organizations in partnership for the achievement of the section activities
  - IERS for space-time references and UTC
  - ITU for UTC dissemination
  - IGS for GNSS applications in UTC
  - ICG for benefiting NMIs of interoperable GNSS
  - IAG for the mutual benefit of the metrological and the geophysical communities

Work - programme 2009 - 2012 (1)

Time scales

- Key comparisons (time, ongoing; frequency; ongoing;…)
- Algorithm for UTC/TAI

  Improving time transfer/ UTC/TAI stability

  - Use of carrier phase (GPS)
  - Implement and currently use GLONASS data in TAI
  - Continuous characterization of delays of lab equipment
    PhD on absolute calibration of GNSS receivers (to conclude by 2011)

  - Clock frequency prediction; improvement of the model for new type of clocks
  - EAL drift; causes, steering

Work - programme 2009 - 2012 (2)

- Frequency transfer/ TAI accuracy
  - Coordinate actions with NMIs developing optical frequency standards (CCTF, CCL-CCTF WG, BIPM)
  - Comparison of highly accurate frequency standards (optical clocks)
    - Potential capabilities of current methods?
    - Comb technology
    - Fibres
    - T2L2, pfs in space (ACES)
  - Coordinate and contribute to comparisons of these standards (*CCL-CCTF requested to draw a questionnaire to be distributed to laboratories for opinion on the contribution of the BIPM to the comparison of frequency standards*)
  - Study the use of secondary representations of the second for the frequency accuracy of TAI, optical clocks

Work - programme 2009 - 2012 (3)

Iodine cells service

- Will be closed as part of the prioritization of activities recently discussed by the Bureau of the CIPM

Gravimetry

- ICAG 2009
- Support to special projects at BIPM
- Operation of the BIPM absolute ballistic gravimeter

Future BIPM (1)

- What do I expect for the BIPM in the next ten years?
- What do NMIs expect from the BIPM ?
- What should the BIPM propose to NMIs ?
- How should the BIPM organize to satisfy the evolving needs?

Future BIPM (2)

- Maintain the highest technical competence in metrology
  - Trained staff
  - Well equipped laboratories
  - Awareness of new trends in metrology

  Consequence: be leaders in our fields of work

- Promote the benefits of having access to an organized structure for metrology
  - NMIs would see the Metre Convention and the CIPM-MRA as the vehicle for accessing to international equivalence in measurements
- Provide support to NMIs in key activities in metrology
  - Consultative Committees
  - NMI directors meetings
  - Coordination as action initiated in the scientific sections
  - Having a voice in international organizations

Future BIPM (3)

- The BIPM should propose
  - A work programme adapted to metrology applied at national level
  - Services to member states to give traceability to national standards through comparisons and calibrations
  - Services adapted to the different levels of needs in member states
  - Technical support to the CIPM-MRA
  - Training programmes based on knowledge of the laboratories requests and the experience of the well-established laboratories + BIPM staff

Future BIPM (4)

- How should the BIPM organize for the challenge?
  - Establishing a long-term scientific programme and strategic plan which should include the totality of coordinated laboratory activities
  - Determining the ensemble of resources for executing the work programme (permanent staff, secondments, PhDs and Post-docs; staff training; equipment)
  - Designing a strategy for presenting to Member States an attractive work programme deserving full financial support
  - Experts in the fields of metrology at CCs should help in transmitting to NMIs and upper levels of decision in their respective countries on their interest in the BIPM activities

TFG in 2013 - 2016 (1)

- Core activities of the section
  - Calculation of UTC/TAI, as mandated by the Member States
  - Gravimetry supporting NMIs and the realization and operation of the watt balance
    - Best estimates of g-differences, gravity gradients and offsets of the individual gravimeters
    - Improve the uncertainty of the g-measurements of the BIPM sites (watt balance)
    - Characterize the BIPM gravimeters (watt balance)

TFG in 2013 - 2016 (2)

- **Increasing our competences in time transfer**
  - New GNSS for clock comparison (GALILEO, other satellite systems coming)
    - Supported by GNSS equipment characterization of delays (relative, absolute)

- **Organizing key comparisons supporting the CIPM-MRA**

TFG in 2013 - 2016 (3)

- **Implementing the use of secondary frequency standards (microwave and optical radiations) for TAI, having achieved accurate frequency comparison**
  - Microwave-microwave
  - Optical-optical
  - Microwave-optical

→ BIPM frequency comb?

Depending on the responses to questionnaire

- **Actively contributing to the discussion and studies on a possible new definition and realization of the second**

- **A sustained action in international organizations we liaise with**

TFG in 2013 - 2016 (4)

- **A steady action for coordinating the network of participating laboratories**
  - Increasing demand of traceability
  - New products for supporting activities in laboratories
  - About 80 participants to UTC foreseen for 2015
  - More training requests
    - Action for coordinating seminars, workshops, tutorials in RMOs, NMIs

TFG in 2013 - 2016 (5)

- **A sustained action in international organizations we liaise with**
  - Re-allocating responsibilities on UTC and TAI at the CGPM/CIPM/CCTF and ITU.
  - Re-enforcing our position at the ICG for enhancing the adoption of time and geodetic standards in GNSS work, thus benefiting NMIs with the interoperability of systems, simplified data handling, lower equipment cost and calibrations.

Staff evolution and requirements

2008 ©

Head(*)

7 physicists (3.6T , 1.5 F, 1.4G)

0.4 SP, 0.1 CCL, WG

1 assistant (T)

3 technicians (2 T, 1 FG)

2009-2012

Head

5 physicists (3.5 T, 0.4 F, 0.8 G)

0.2 SP, 0.1 CCL, WG

1 assistant (T)

2 technicians (2T, 0 FG)

1 PhD

2 physicists, 1 technician retiring

2013-2016

Head

5/6 physicists (3.5T, 1F, 1.5 G)

1 assistant (T)

2.5/3 technicians (2T,1FG)

1 Post Doc

PhD (1/2)

Increase staff for delivering the work programme oriented to support NMIs

Staff number should be stable in the period.

© Got back two positions lost in 2003 and 2007

(*) International coordination, Time, Frequency, CCTF,CCL