

Report to the 18th Session of the CCTF

Working Group on Primary Frequency Standards

Thomas E. Parker, Chair

Introduction

The Working Group on Primary Frequency Standards (WGPFS) was organized in 2005. The membership includes 21 individual from 13 metrology organizations, including the Time Section of the BIPM. The current Chairman is Thomas Parker from the National Institute of Standards and Technology (NIST) in Boulder, USA. A list of members is included in Appendix A.

There are now eight laboratories that are regularly reporting to the BIPM the results of formal evaluations from nine Cs fountains and four thermal beam standards. For about the last two years an average of between 3 and 4 fountains have been reported in each Circular T. The large number of regularly reporting primary standards reflects a very healthy community.

Terms of Reference

The terms of reference for the WGPFS are given in Appendix B.

Meetings

The working group has held four meetings since 2005. These include a meeting in August 2005 at the Joint meeting of the IEEE International Frequency Control Symposium (IFCS) and the Precise Time and Time Interval (PTTI) Systems & Applications Meeting in Vancouver, Canada, and in March 2006 at the European Frequency and Time Forum (EFTF) in Braunschweig, Germany. In May 2007 a one day Workshop on Primary Frequency Standards was held in connection with the joint EFTF/IFCS in Geneva Switzerland. The workshop was very successful with 8 presentations and 34 registered attendees (plus a few walk-ins). The main topic of the workshop was “lessons learned” as presented by scientists from laboratories already operating a PFS, as well as the BIPM. Representatives from all the metrology laboratories interested in primary frequency standards were present. A forth meeting of the WGPFS was held in April 2008 at the EFTF in Toulouse, France.

Activities of the WGPFS

(1) Uncertainty of frequency transfer based on data published in Circular T. The uncertainties UTC - UTC(k) are now published in Circular T and, when they are used, this result in a significantly reduced frequency transfer uncertainty as compared to the expression that had been used by the BIPM for a PFS until August 2006. The reduced uncertainty has resulted from improved time/frequency transfer techniques such as two-way, multi-channel GPS receivers, and the IGS ionosphere maps. In March 2006 the WGPFS recommended a change in the way the frequency transfer uncertainty be calculated for a PFS reporting into TAI. In September 2006 this change was

implemented. Papers on the general topic of frequency transfer uncertainty and the specific topic of frequency transfer uncertainty in reporting a PFS to TAI were presented at the 2007 joint EFTF/IFCS meeting by G. Panfilo and T. Parker. Recently an updated manuscript on the same topics was submitted to Metrologia.

(2) Consultation on new standards and significant changes in uncertainty. According to the CCTF Recommendation CCTF/06-08, the first report of a new primary frequency standard (PFS), as well as those from frequency standards whose uncertainties have changed appreciably will be circulated to the Working Group on Primary Frequency Standards (WGPFS) for comments before the report is accepted by the Bureau International des Poids et Mesures (BIPM).

In accord with this recommendation the first report of NICT-CsF1, a new cesium fountain which is operated by the Time-Space Standards Group of the National Institute of Information and Communications Technology (NICT) in Tokyo, Japan was circulated in July 2007 to the WGPFS for comment. After comments and discussion, the working group recommended that the report be accepted with minor changes.

In October 2008, the working group was consulted again regarding a significant decrease in the uncertainty of NICT-CsF1. This consultation was handled by the working group chairman since the reason for the change was fairly basic.

In January 2009, the first report of KRIS-1, a new optically pumped thermal beam standard operated by the Korea Research Institute of Standards and Science in Daejeon, Korea was circulated to the working group for comment. The working group recommended that report be accepted with minor changes.

(3) Email discussions on PFS uncertainties that change over time.

The change in the uncertainty of NICT-CsF1 prompted a discussion in early 2009 as to whether there should be a specified fractional change in uncertainty that would trigger a consultation with the working group. The consensus within the group was not to assign a specific number, but to leave it up to the discretion of the BIPM.

Another issue that came up for discussion at the same time was the fact that values of the Type B uncertainties that appear in Circular T may sometimes differ significantly from what is stated in the referenced peer reviewed journal article. This generally occurs because uncertainties are gradually decreased as a standard matures. In many cases the incremental decreases in Type B uncertainties do not warrant a publication in themselves, but at some point the accumulated changes should be documented in a peer reviewed journal. The question came up as to at what point an updated peer reviewed journal article should be required. The working group felt that no specific criteria should be imposed, but that the decision should be left to the individual laboratories. The working group urges all laboratories operating a PFS to periodically update the documentation of the standard in peer reviewed journals when appropriate.

Future Meetings

Future meetings will be held as it is felt necessary. This should nominally be about once per year. Much of the business of the working group can be carried out via e-mail.

Appendix A

Members of the Working Group on Primary Frequency Standards

Chair: T. Parker (NIST)

BIPM	G. Petit, F. Arias
LNE-SYRTE	A. Clairon, S. Bize
INRIM	A. Godone, F. Levi
KRISS	Ho Seong Lee, Taeg Yong Kwon
METAS	Andre Stefanov
NICT	M. Hosokawa
NIM	Tianchu LI
NIST	S. Jefferts, T. O'Brian
NMIJ/AIST	T. Ikegami, Shinichi Ohshima
NPL	Krzysztof Szymaniec
NRC	Louis Marmet
PTB	A. Bauch, R. Wynands
VNIIFTRI	Y. Domin

Appendix B

**Working Group on Primary Frequency Standards
Terms of Reference**

Members

The working group is made up of:

- representatives of all National Metrology Institutes (NMIs) that operate Primary Frequency Standards (PFSs) reporting to TAI,
- representatives of NMIs that are planning to operate at least one PFS reporting to TAI,
- representatives of the BIPM.

Chairperson

The chairperson is a member of the Working Group on Primary Frequency Standards representing an NMI operating a PFS appointed by the CCTF for the term of two consecutive CCTF meetings.

Objectives

- (1) Develop and propose standards for the documentation of frequency biases and uncertainties, operational details, and frequency transfer uncertainties for a PFS. Develop and propose standards for the reporting of the results of a PFS evaluation to the BIPM.
- (2) Provide a forum to evaluate and discuss the consistency among primary frequency standards.
- (3) Provide a forum to discuss and assess the overall knowledge of the accuracy of the SI second for use in establishing the frequencies of secondary standards (microwave and optical) and possibly an eventual redefinition of the second.
- (4) Interact with the BIPM on issues related to PFS contributions to the accuracy of TAI, particularly in the process of integration of the first reports of a standard.
- (4) Encourage and facilitate direct comparisons between primary frequency standards.
- (5) Encourage and support laboratories with new standards under construction.