# TABLE OF CONTENTS

Distinguished PTTI Service Award .................................................. 1

Presented by
Dr. Joseph D. White
U.S. Naval Research Laboratory
to
Dr. Judah Levine
National Institute of Standards and Technology (NIST)

Opening Remarks ................................................................. 3

Capt. R. Scott Steadley
U.S. Naval Observatory

**SESSION I**

**TIME FROM GNSS**

Rachel Evans-Binfield, Chairman
Johns Hopkins University

Use of GLONASS at the BIPM ..................................................... 5

W. Lewandowski and Z. Jiang, Bureau International des Poids et Mesures

EGNOS Network Time and Its Relationships to UTC and GPS Time ............... 15

J. Delporte, N. Suard, CNES – French Space Agency; D. Sidorov, Paul Sabatier University, France; and P. Ulrich, LNE-SYRTE, LNE, CNRS, UPMC, Observatoire de Paris, France

The Common Time Module, a Robust Time Maintenance System .................. 33

A. Dowd and M. Garvey, Symmetricom, Inc.
SESSION II

PTTI VENDOR PRESENTATIONS

Tony DiFlorio, Chairman
Spectracom

Presentations were made by GPS Source; ITT; JTime! And Lange Electronics, GmbH; Linear Photonics; Magic GNSS; Masterclock; Morion, Inc.; PIK Time Systems; Spectracom/Pendulum Instruments; SpectraTime; Symmetricom, Inc.; Synergy Systems, LLC; Timetech GmbH; and TRAK Microwave Corporation

SESSION III

TIME TRANSFER TECHNIQUES

Francine Vannicola, Chairman
U.S. Naval Research Laboratory

Study of Frequency Transfer via Optical Fiber in the Microwave Domain .......................... 45
M. Amemiya, M. Imae, Y. Fujii, T. Suzuyama, K. Watabe, T. Ikegami, National Metrology Institute of Japan (NMIJ); and H. Tsuchida, National Metrology Institute of Japan (NMIJ) and Photonics Research Institute, National Institute of Advanced Industrial Science and Technologies (AIST)

Fiber-Based Frequency Distribution Based on Long-Haul Communication Lasers .................. 57
S. Ebenhag, P. Hedekvist, SP Technical Research Institute of Sweden and Chalmers University of Technology, Sweden; and K. Jaldehag, SP Technical Research Institute of Sweden

Time Transfer by Laser Link – T2L2: Results of the First Year of Operation ..................... 67
P. Guillemot, CNES – French Space Agency; P. Exertier, E. Samain, F. Pierron, J. Torre, Observatoire de la Côte d’Azur, France; and S. Leon, CNES – French Space Agency

High-Performance RF Optical Links ................................................................. 81
S. Crane, C. Ekstrom, P. Koppang, and W. Walls, U.S. Naval Observatory

Time Transfer through Optical Fibers (TTTOF): First Results of Calibrated Clock Comparisons ... 89
Dirk Piester, Physikalisch-Technische Bundesanstalt (PTB), Germany; Miho Fujieda, National Institute of Information and Communications Technology (NICT), Japan; Michael Rost, and Andreas Bauch, Physikalisch-Technische Bundesanstalt

Limits on GPS Carrier-Phase Time Transfer .......................................................... 101
M. Weiss, National Institute of Standards and Technology
Implementation and Comparison of Time and Frequency Transfer Methods by GPS Carrier Phase
K. Liang and A. Zhang, National Institute of Metrology, China

SESSION IV

ALGORITHMS

George Shaton, Chairman
Department of Defense

An Anomaly Clock Detection Algorithm for a Robust Clock Ensemble
Q. Wang and P. Rochat, SpectraTime, Switzerland

Negative Power Law Noise, Reality vs. Myth
V. Reinhardt, Raytheon Space and Airborne Systems

Frequency and Phase Break Detection
Scott Czopek

Prototype of the DLR Operational Composite Clock: Methods and Test Cases
M. Suess and J. Hammesfahr, German Aerospace Centre, Germany

SESSION V

POSTER SESSION

Rachel Evans-Binfield, Chairman
Johns Hopkins University

(Papers have been reassigned in these Proceedings to Sessions III, IV, VIII, X, XI, XII.)
SESSION VI
NATIONAL LAB UPDATE (I)

Edoardo Detoma, Chairman
SEPA S.p.A.

Activities and Updates at the State Time and Frequency Standard of Russia .......................... 175
Y. Domnin, N. Koshelyaevsky, V. Kostromin, P. Krasovsky, and V. Palchikov,
FGUP “VNIIFTRI,” Russia

BIPM Time Activities Update .................................................. 183
A. Harmegnies, G. Panfilo, International Bureau of Weights and Measures (BIPM), France; and
E. F. Arias, International Bureau of Weights and Measures and Paris Observatory, France

METAS Time and Frequency Metrology Report ..................................... 189
L. Bernier, A. Stefanov, and C. Schlunegger, METAS Federal Office of Metrology, Switzerland

PTB’s Time and Frequency Activities in 2008 and 2009 .......................... 197
M. Rost, A. Bauch, J. Becker, T. Feldmann, D. Piester, T. Polewka, D. Sibold, and
E. Stalvuniene, Physikalisch-Technische Bundesanstalt, Germany

The Timing Activities of the National Time and Frequency Standard Laboratory of the
Telecommunication Laboratories, CHT Co., Ltd., Taiwan .......................... 215
P. Chang, J. Wang, H. Lin, S. Lin, W. Tseng, C. Lin, F. Chu, and C. Liao, Chunghwa Telecom
Co., Ltd., Taiwan

SESSION VII
NATIONAL LAB UPDATE (II)

Leo Mallette, Chairman
The Aerospace Corporation

Time and Frequency Activities at NICT, Japan ................................... 221
Y. Koyama, K. Imamura, T. Iwama, S. Hama, J. Amagai, R. Ichikawa, and M. Hosokawa,
National Institute of Information and Communications Technology, Japan

Time and Frequency Activities at SP in Sweden .................................. 231
K. Jaldehag, SP Technical Research Institute of Sweden; C. Rieck, and S.-C. Ebenhag,
SP Technical Research Institute of Sweden and Chalmers University of Technology, Sweden

Time and Frequency Activities at the JHU Applied Physics Laboratory .................. 253
M. Miranian, G. Weaver, M. Reinhart, and R. Dragonette, Johns Hopkins University
Time and Frequency Activities at the U.S. Naval Observatory ........................................ 261
D. Matsakis, U.S. Naval Observatory

Recent Timing Activities at the U.S. Naval Research Laboratory ................................. 283
R. Beard, O. Oaks, K. Senior, and J. White, U.S. Naval Research Laboratory

SESSION VIII

CALIBRATION: RECEIVERS AND SYSTEMS

Sam Stein, Chairman
Symmetricom

Time Stability and Electrical Delay Comparison of Dual-Frequency GPS Receivers .............. 293
A. Proia, Centre National d'Etudes Spatiales and Bureau International des Poids et Mesures,
France; G. Cibiel, Centre National d'Etudes Spatiales; and L. Yaigre, Sogeti High-Tech,
France

Phase-Lock Loops in Vibration Environments .............................................................. 303
A. Hati, C. Nelson, and D. Howe, National Institute of Standards and Technology

Proficiency Testing Activities of Frequency Calibration Laboratories in Taiwan, 2009 .......... 313
H. Lin, P. Chang, J. Wang, and C. Liao, Chunghwa Telecom Co., Ltd., Taiwan

Clock Comparison Using Digital Television Signals ...................................................... 319
D. Boehm, J. White, U.S. Naval Research Laboratory; S. Mitchell, and E. Powers, U.S. Naval
Observatory

Design and Implementation of a Time Source Selecting and Monitoring System for the Telephone
Speaking Clock ................................................................................................................ 327
C. Lin, P. Chang, J. Wang, and S. Lin, Chunghwa Telecom Co., Ltd., Taiwan

Characterization of Noise Properties in Photodetectors: A Step toward Ultra-Low Phase Noise
Microwaves ..................................................................................................................... 339
J. Taylor, University of Colorado and National Institute of Standards and Technology;
F. Quinlan, and S. Diddams, National Institute of Standards and Technology
SESSION IX

FUTURE PTTI WORKSHOP

James Camparo, Chairman
The Aerospace Corporation

A Glimpse of the Future: The 62nd PTTI Systems and Applications Meeting November 2030
L. Mallette and J. Camparo, The Aerospace Corporation

SESSION X

TIME TRANSFER – DATA TREATMENTS

Steven Jefferts, Chairman
National Institute of Standards and Technology

Optimal Time Transfer .............................................. 359
J. Wright and J. Woodburn, Analytical Graphics, Inc.

Two-Way Satellite Time and Frequency Transfer Using 1 Mchip/s Codes ......................... 371
V. Zhang, T. Parker, National Institute of Standards and Technology; J. Achkar, Observatoire
de Paris, LNE, CNRS, UPMC, France; A. Bauch, Physikalisch-Technische Bundesanstalt,
Germany; L. Lorini, Istituto Nazionale di Ricerca Metrologica, Italy; D. Matsakis, U.S. Naval
Observatory; D. Piester, Physikalisch-Technische Bundesanstalt; and D. Rovera, Observatoire
de Paris, LNE, CNRS, UPMC, France

Time and Frequency Transfer Using Asynchronous Fiber-Optical Networks: Progress Report ...... 383
K. Jaldehag, S. Ebenhag, P. Hedekvist, C. Rieck, SP Technical Research Institute of Sweden;
and P. Löthberg, STUPI, L.L.C.

Novel, All-Digital Phase Measurement System for Time Scales .................................. 397
S. Römisch, National Institute of Standards and Technology and Spectral Research;
T. Parker, and S. Jefferts, National Institute of Standards and Technology

TWSTFT Data Treatment for UTC Time Transfer ................................................. 409
Z. Jiang, W. Lewandowski, and H. Konaté, Bureau International des Poids et Mesures,
France

Detection of Outliers in TWSTFT Data Used in TAI ........................................... 421
A. Harmegnies, G. Panfilo, and E. Arias, International Bureau of Weights and Measures,
France
SESSION XI

SPACE CLOCKS AND PANEL

Leo Mallette, Chairman
The Aerospace Corporation

RESSOX Control of QZSS During Communication Interruption ........................................... 433
T. Iwata, T. Matsuzawa, National Institute of Advanced Industrial Science and
Technology, Japan; and A. Abei, Cosmo Research Corporation, Japan

GPS Block IIF Rubidium Frequency Standard Life Test ...................................................... 449
F. Vannicola, R. Beard, J. White, K. Senior, T. Kubik, D. Wilson, U.S. Naval Research
Laboratory; and J. Buisson, Antoine Enterprises, Inc.

What We Don’t Know about Quartz Clocks in Space ............................................................ 457
M. Bloch, O. Mancini, and T. McClelland, Frequency Electronics, Inc.

Investigations into the Rb Clock’s 2nd Harmonic Signal: A Status Report ......................... 473
G. Fathi and J. Camparo, The Aerospace Corporation

SESSION XII

ADVANCED CLOCKS

Ryan Dupuis, Chairman
PerkinElmer

TCMO: A Versatile MEMS Oscillator Timing Platform ......................................................... 481
K. Schoepf, R. Rebel, D. Chen, G. Zolfaghar, A. Gaidarzy, J. Kuyppers, M. Crowley,
and P. Mohanty, Sand 9, Inc.

Space Passive Hydrogen Maser–Performances, Lifetime Data, and GIOVE-B-Related
Telemetries ...................................................................................................................... 493
M. Belloni, M. Gioia, S. Beretta, Selex Galileo, Italy; F. Droz, P. Mosset, Q. Wang,
P. Rochat, SpectraTime, Switzerland; A. Resti, P. Waller, and A. Ostillio, European Space
Agency/ESTEC, Netherlands

Micro Ion Frequency Standard ............................................................................................. 509
P. Schwindt, R. Olsson, K. Wojcilechowski, D. Serkland, T. Statom, H. Partner,
G. Biedermann, L. Fang, A. Casias, and R. Manginell, Sandia National Laboratories

A Space Rubidium Pulsed Optical Pumped Clock–Current Status, Results, and Future
Activities ......................................................................................................................... 519
M. Belloni, A. Battisti, A. Cosentino, A. Sapia, A. Borella, Selex Galileo, Italy;
SESSION XIII

RECEIVER BIASES

S. Clark Wardrip, Chairman
Global Strategies Group North America

Local Oscillator Contribution to Carrier-Phase Measurements in a GNSS Receiver .................. 537
E. Detoma, L. Bonafede, and P. Capetti, Sistemi Elettronici Per l’Automazione S.p.A.,
Italy

Tracking Biases Caused by Imperfections in DLL Receivers .......................... 551
G. Hejc and W. Schaefer, TimeTech GmbH, Germany

Evaluation of the Time and Frequency Transfer Capabilities of a Network of GNSS Receivers
Located in Timing Laboratories .............................................................. 559
R. Piriz, GMV Aerospace and Defence, S.A., Spain; G. Cerretto, A. Perucca, and P. Tavella,
Istituto Nazionale di Ricerca Metrologica, Italy

List of Attendees ................................................................. 575