# Task Group Study on Long-term Comparison between GPS and TW Links — Review and Preview

Victor Zhang and Zhiheng Jiang

# Summary of Activities (1)

- Opening Remarks – Z. Jiang, PS meeting during the PTTI 2016 (presentation is available on the restricted access WG folder, WGTWSTFT/UTC)
- Proposal of preliminary study objective and actions has been distributed among task group members (see Appendix I)
- Some publications on previous studies of the instability of GPS and TW links are collected (see Appendix II for the list, collected publications are available on the WG restricted access folder, more publications on this subject are welcome)

# Summary of Activities (2):

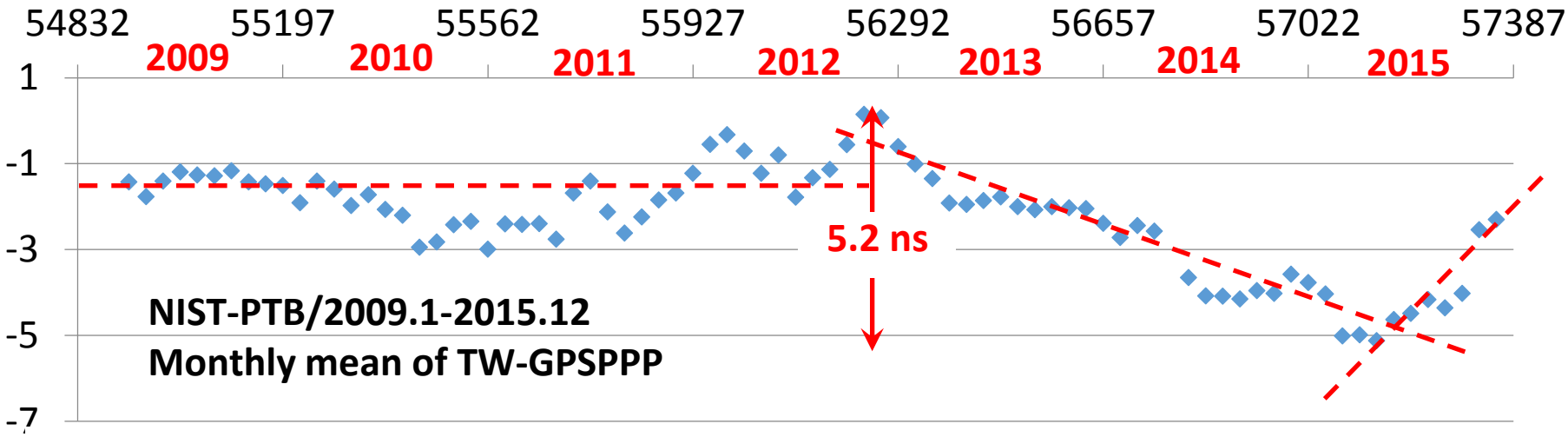
- Discussions started on how to proceed the study:
  - monitor the stability of a GPS or TW link with the common-clock difference of co-located GPS receivers or TW stations
  - use both GPS P3 and carrier-phase data in the study
  - review the GPS and TW calibration records
  - follow the TW mobile calibrations of the USNO/PTB (yearly) and Europe-to-Europe (every two years) links
  - follow the BIPM/RMO G1/G2 GNSS calibrations (for both GPS and TW links)
  - correlate the link delay variation with environment and setup changes
  - compare GPS and TW links with other links such as broadband TW, optical fiber link and ACES MWL

# Summary

- 7 years' variation between TW-GPSPPP UTC links
- The causes of the variations:
  - what we do not know ? → many
    - TW or GPS or both or the pivot (PTB)
  - What we know ? → almost nothing for long-terms'
    - a few particular cases short-middle terms (≤ 1yr):
      - Setup, neglected changes
      - Environment, in/outside temperature
      - Calibrations:
        - Link calibration
        - Receiver calibration
- Solutions ? → ??
- Starting points for the task group ?

# 7 year comparison of TWSTFT-GPSPPP UTC links



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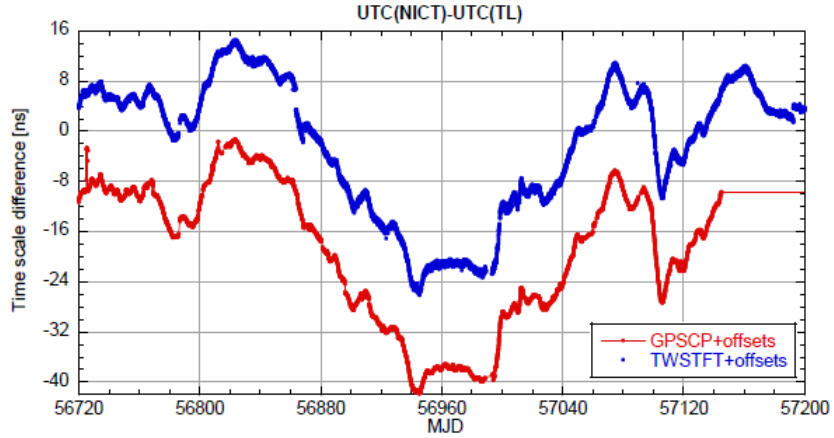
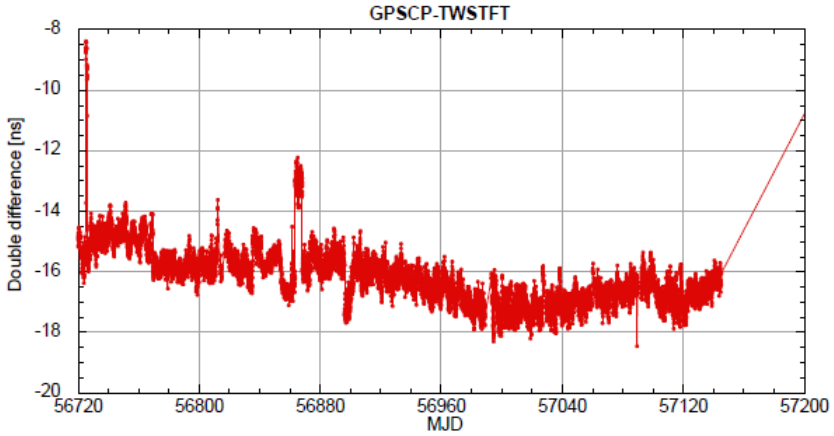
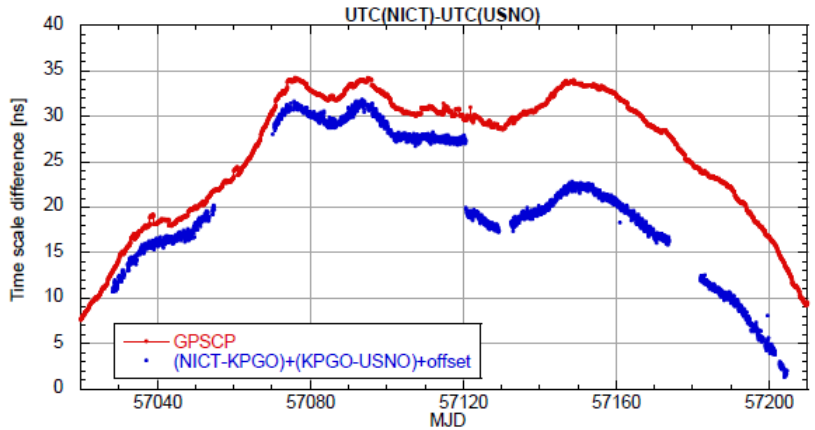
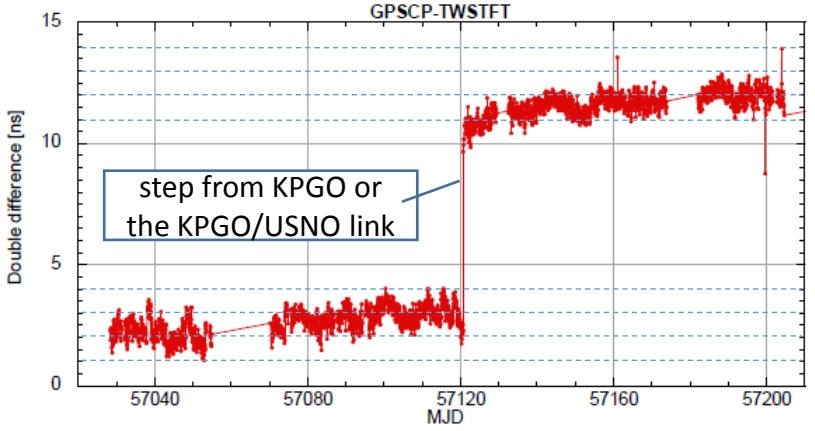
# The first tasks of the Task Group

- Members: Z Jiang, V Zhang, J Achkar, A Bauch, D Piester, M Fujieda, C Lin, K Liang, T Parker, D Matsakis, P Defraigne, G Petit
- Review and analyze the comparisons of TW and GPS for the Asia, Europe, US and intercontinental links to select the links of the study
- Investigation of the causes of the changes and variations
- Some hints:
  - temperatures
  - calibrations
  - setups, more attention on GPS
  - aging of the electronic pieces ?
  - uses of other techniques: optical fibre, Glonass, P3, C/A, L1C etc.
- Report to TW WG annual meeting



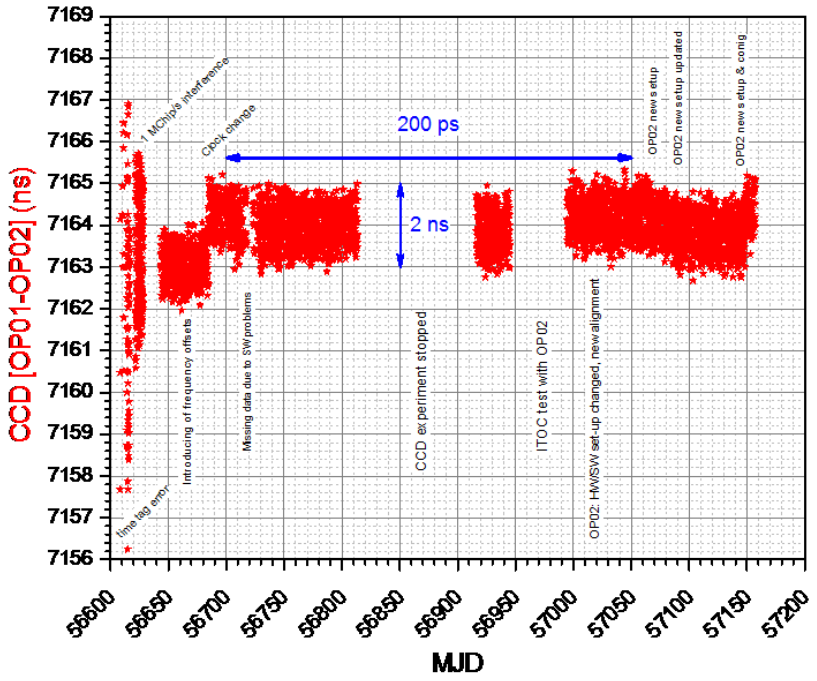



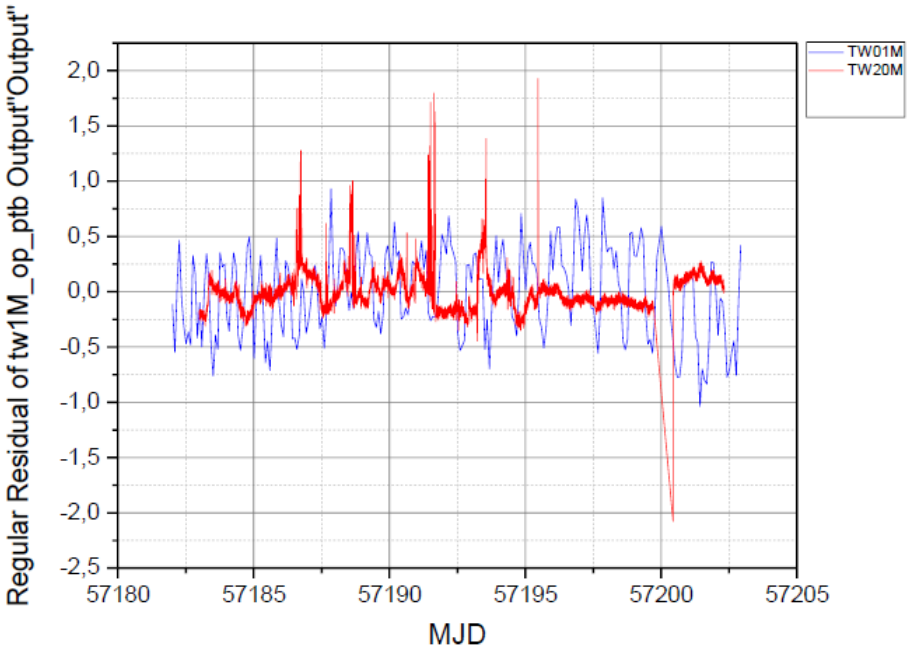




Analysis provided by Miho Fujieda, NICT.

The mean of NICT/TL double difference might contain a component of annual variation. The NICT/KPGO/USNO double difference shows (an accumulated) 2ns change over about 6 months.




Analysis provided by Joseph Achkar, OP.

The mean of OP01/OP02 common-clock difference remains a constant over 1.5 years. The mean of the OP/PTB 1MChip/s and 20MChip/s (broadband) TW double difference shows a good agreement over 20 days (using another technique to check the TW link variation).

# Appendix I:
# Proposal for the task group study on long-term comparison between GPS and TW links

Dear task group colleagues,

First, we would like to thank you for your participation in the task group study! After the opening remarks made by Zhiheng at the PS meeting (see the attached presentation), we would like to have the study started.

We propose the following preliminary study objective and actions.

Objective: Study the stability (worst, typical, best) of GPS and TW links for a time period longer than one year and to identify the origins of the link instability.

Actions (not limited by the listed items, any additional suggestions are welcome):

- Review previous studies and researches on the instability of GPS and TW links
- Examine the repeated calibrations of GPS equipment and TW links for estimations of the long-term link stability
- Evaluate the relative link instability between GPS and TW using the double difference method
- Identify sources of instability for the specific links
  - seasonal and annual variations
  - drifts
  - time steps
- Recommend actions to maintain the long-term stability of GPS and TW links

We appreciate your comments and suggestions on the objective and actions. Please identify your contributions to the study. We plan to have a discussion on the study at the PS meeting during EFTF 2016 in April.

With best regards,

Zhiheng Jiang and Victor Zhang

# Appendix II:
# List of publications on previous studies of the instability of GPS and TW links


1. D. Matsakis, K. Senior and P. Cook, “Comparison of Continuously Filtered GPS Carrier-phase Time and Frequency Transfer with Independent Daily GPS Carrier-phase Solutions and With Two-Way Satellite Time Transfer”, 33rd PTTI, 2001
2. S. Lin, W. H. Tseng, H. T. Lin, Y. J. Huang and K. M. Feng, “Long-term Inconsistency TWSTFT and GPS Time Transfer Results in PTB-TL and NICT-TL Time Links”, 24th EFTF, 2010
3. Z. Jiang, D. Matsakis, S. Mitchell, L. Breakiron, A. Bauch, D. Piester, H. Maeno and L. G. Bernier, “Long-term Instability of GPS-based Time Transfer and Proposals for Improvements”, 43rd PTTI, 2011
4. D. Matsakis, “Time and Frequency Activities at the U.S. Naval Observatory”, 43rd PTTI, 2011
5. S. Lin, Y. J. Huang and W. H. Tseng, “Uncertainty Evaluation of 2013 TL METODE Link Calibration Tour”, 29th EFTF, 2015