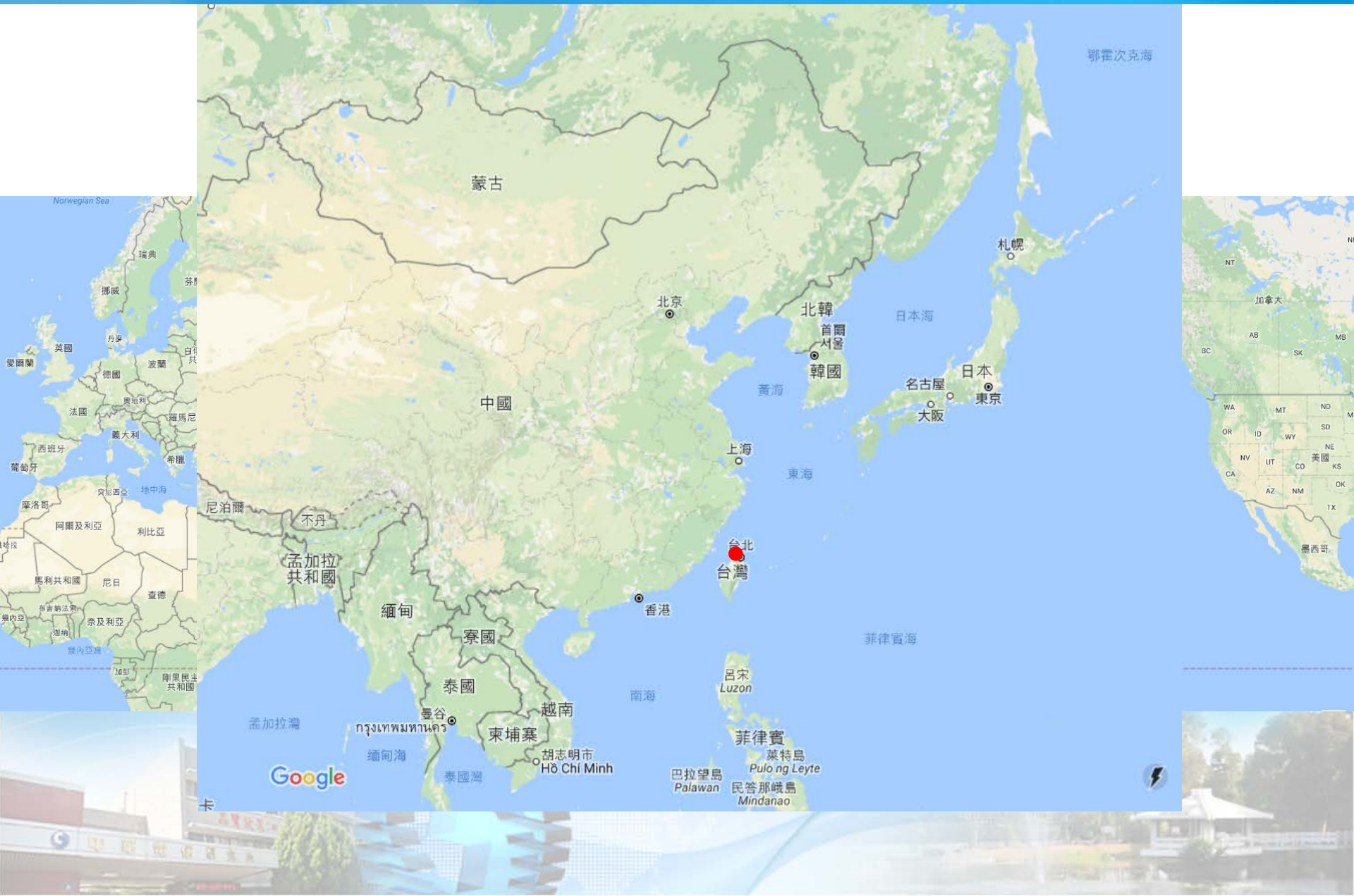
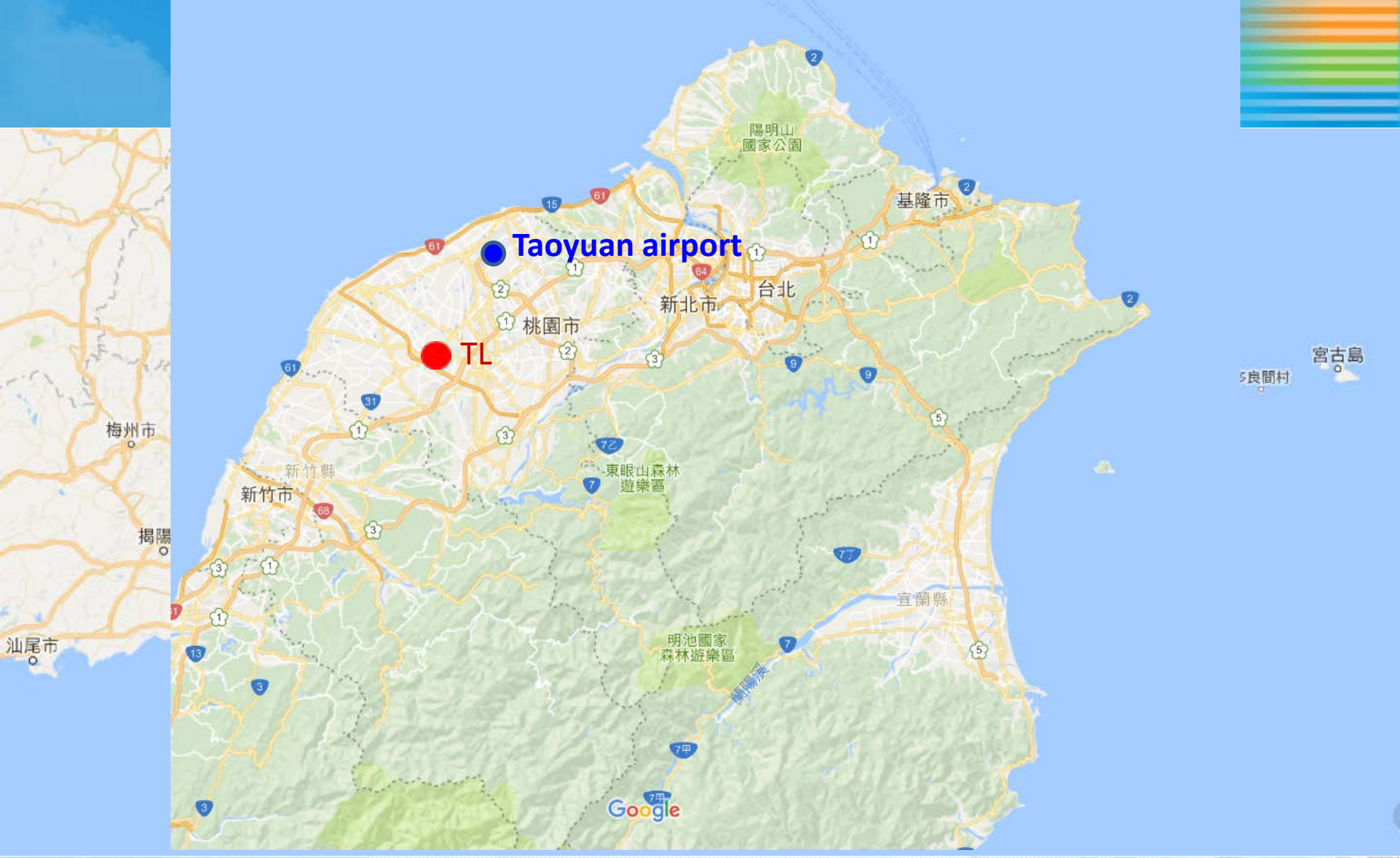
Time and Frequency Activities TL, Chinese Taipei

Huang-Tien LIN and Chia-Shu Liao

the 21st CCTF meeting
June 08-09, 2017

Where is TL?


鄂霍次克海
蒙古
札幌
北京
北韓
首爾
서울
日本海
韓國
黃海
名古屋
日本
東京
大阪
中國
上海
東海
台北
台灣
香港
菲律賓海
呂宋
Luzon
南海
泰國
越南
柬埔寨
胡志明市
Hồ Chí Minh
菲律賓
萊特島
Pulo ng Leyte
巴拉望島
Palawan
民答那峨島
Mindanao
緬甸
寮國
孟加拉灣
緬甸海
泰國灣
Google



- TL is responsible for the time and frequency standard of Taiwan
- An associate member of CGPM, and TL has attended CCTF meeting as a guest since 1999.
  - - ITRI/CMS has joined in CCL and CCAUV as an Observer

1. **Introduction**

   T&F national standard, UTC(TL), TA(TL)

2. Precise time and frequency transfer

   GPS、TWSTFT, and Optical fiber

3. Time Dissemination Services

   NTP and speaking clock services

4. International Cooperation

   Workshops and Training activities

5. Publications

1. Introduction

Reference clocks of TL

- 10 Microsemi 5071A cesium clocks with high performance tubes
- 4 active Hydrogen masers
  located in the 4 EM shielding chambers with stabilized temperature (23±1˚C) and humidity (50±5%) .

UTC(TL) & TA(TL)

- TA(TL) is a weighted result of our cesium-clock ensemble. The output frequency of our master hydrogen maser is steered by a micro-phase-stepper (Microsemi AOG-110) to generate UTC(TL).
- The performance of UTC(TL) was checked by referring to TA(TL) and the Circular-T data to ensure its accuracy.
- The phase difference between UTC(TL) and UTC was kept within **±30 ns**, and its stability is about **4E-15** with averaging time of 5 days.
- **Contribution to the calculation of TAI ~ about 1.3% (Ranked about 15)**

TL's link on BIPM webpage

Bureau International des Poids et Mesures

– the intergovernmental organization through which Member States act together on matters related to measurement science and measurement standards.

Search facility:

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> You are here: BIPM > Associates > Chinese Taipei > links

Associate: Chinese Taipei / Useful links

General info. | CIPM MRA | Links

Metrology institutes

BSMI** (Bureau of Standards, Metrology and Inspection)
TL* (Telecommunication Laboratories, ChungHwa Telecom Co. Ltd.)
CMS* (ITRI Center for Measurement Standards)
INER* (Institute of Nuclear Energy Research)
NML (National Measurement Laboratory)

National legal metrology authorities

Bureau of Standards, Metrology and Inspection (BSMI)

National accreditation bodies

Taiwan Accreditation Foundation (TAF)

** Signatory of the CIPM MRA ; * Also participating in the CIPM MRA.

Other Associates

--> Select State/Economy

Related articles

- Services available to Associate States and Economies
- The CIPM MRA
- Participants in the CIPM MRA
- List of Member States

Meetings:

- NMI Directors and State Representatives

Metrology area: AUV | EM | L | M | PR | QM | RI | T | TF | U

BIPM - Pavillon de Breteuil F-92312 Sèvres Cedex FRANCE

Disclaimer

TL's CMC Publication on BIPM KCDB

Calibration and Measurement Capabilities

Time and Frequency, Chinese Taipei, TL (Telecommunication Laboratories, ChungHwa Telecom Co. Ltd.)

KCDB

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty						
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum value	Maximum value	Units	Parameter	Specifications	Value	Units	Coverage factor	Level of Confidence	Is the expanded uncertainty a relative one?	NMI Service Identifier	Comments
Time interval	Time difference source	Direct time interval measurement	-1000	1000	s	1 PPS amplitude	> 0.5 V (50 Ω)	1.0	ns	2	95%	No	NSTF-ICT-SR620A-005	Included best DUT's effect Approved on 10 March 2015
						Measurement time	86400 s							
						Slew rate	> 0.5 V/ns							
Time scale difference	Local clock vs. UTC	Comparison against predicted UTC	-0.5	0.5	s	1 PPS amplitude	> 0.5 V (50 Ω)	100	ns	2	95%	No	NSTF-ICT-SR620A-005	Included best DUT's effect Approved on 10 March 2015
						Measurement time	86400 s							
						Slew rate	> 0.5 V/ns							
Time scale difference	Remote clock vs. UTC	GPS common-view time transfer	-0.5	0.5	s	Averaging time	1 d	35	ns	2	95%	No	NSTF-ICT-RTFCS-002	Included best DUT's effect Approved on 10 March 2015
						Baseline length from TL	< 1000 km							
Frequency	General frequency source	Direct frequency measurement	1	3.0E+08	Hz	Measurement time	86400 s	3.0E-12	Hz/Hz	2	95%	Yes	NSTF-ICT-SR620B-005	Included best DUT's effect Approved on 10 March 2015
						Amplitude	> 0.5 V (50 Ω)							
Frequency	Local frequency standard	Phase comparison	1	1	MHz	Measurement time	86400 s	3.0E-13	Hz/Hz	2	95%	Yes	NSTF-ICT-SR620C-005	Included best DUT's effect Approved on

9 items with 7 calibration systems

TL's information in Circular-T

CIRCULAR T 346
2016 NOVEMBER 10, 15h UTC

ISSN 1143-1393

BUREAU INTERNATIONAL DES POIDS ET MESURES
ORGANISATION INTERGOUVERNEMENTALE DE LA CONVENTION DU METRE
PAVILLON DE BRETEUIL F-92312 SEVRES CEDEX TEL. +33 1 45 07 70 70 FAX. +33 1 45 34 20 21 tai@bipm.org

The contents of the sections of BIPM Circular T are fully described in the document "Explanatory supplement to BIPM Circular T" available at ftp://ftp2.bipm.org/pub/tai/publication/notes/explanatory_supplement_v0.1.pdf

1 - Difference between UTC and its local realizations UTC(k) and corresponding uncertainties.
From 2015 July 1, 0h UTC, TAI-UTC = 36 s. From 2017 January 1, 0h UTC, TAI-UTC = 37 s.

Date 2016 0h UTC	SEP 28	OCT 3	OCT 8	OCT 13	OCT 18	OCT 23	OCT 28	Uncertainty/ns			Notes
MJD	57659	57664	57669	57674	57679	57684	57689	uA	uB	u	
Laboratory k	[UTC-UTC(k)]/ns										
AOS (Borowiec)	-1.5	-0.2	0.9	0.9	1.0	1.0	1.1	0.4	2.7	2.7	
APL (Laurel)	2.7	2.5	2.1	0.8	-1.7	-2.7	-2.0	0.3	10.9	10.9	
AUS (Sydney)	862.1	894.0	914.3	924.4	955.5	967.0	982.5	0.4	5.9	5.9	
BEV (Wien)	29.0	26.2	20.0	23.4	24.1	26.2	41.6	0.3	2.6	2.7	
...											
TL (Chung-Li)	6.1	7.6	8.9	9.1	9.7	10.2	10.6	0.3	2.2	2.2	
TP (Praha)	-24.8	-17.4	-14.0	-7.7	-2.9	2.1	9.4	0.3	5.8	5.8	
UA (Kharkov)	8.2	5.0	-1.1	-0.7	1.4	6.4	17.2	1.5	8.1	8.3	
UME (Gebze-Kocaeli)	-62.4	-68.1	-71.3	-73.9	-69.2	-74.8	-77.1	0.5	7.3	7.3	
USNO (Washington DC)	0.6	0.7	0.4	-0.2	-0.1	0.3	0.4	0.2	1.0	1.1	
VMI (Ha Noi)	-2.5	2.3	18.9	23.6	19.1	22.5	19.9	1.3	20.0	20.1	(3)
VSL (Delft)	1.7	-4.4	-9.3	-13.4	-10.6	-1.1	4.7	0.3	1.3	1.4	
ZA (Pretoria)	6.9	6.0	7.5	9.0	7.6	5.8	6.1	0.4	20.0	20.0	

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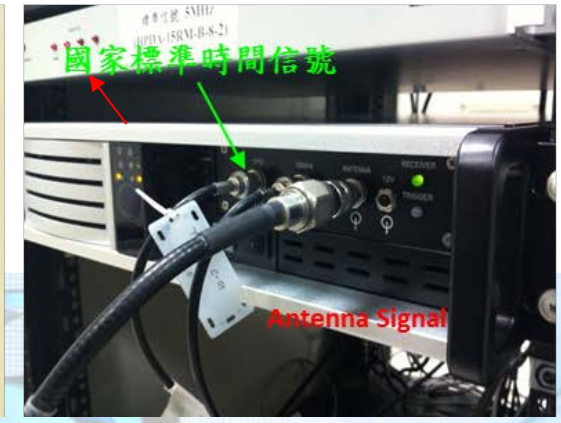
Time and Frequency Transfer -- GPS

Participate in the ongoing key comparison ~ CCTF-K001.UTC

- Report GPS measurement data continuously to BIPM
- Contribute to the generation of TAI and UTC

TTS4

GTR50



PolaRx4

GNSS time transfer system - Antennas and receivers

Annex 5

V1.0-15 April 2014

Group 1 and Group 2 laboratories

On the basis of the criteria established in section A3.1 and at the request of the BIPM, Regional Metrology Organizations proposed laboratories for being included in the Group 1. Letters of commitment from the relevant authorities in the Group 1 proposed laboratories have been received. Table 1 shows the contributing laboratories in each region, the Group 1 in red characters, the Group 2 in black characters.

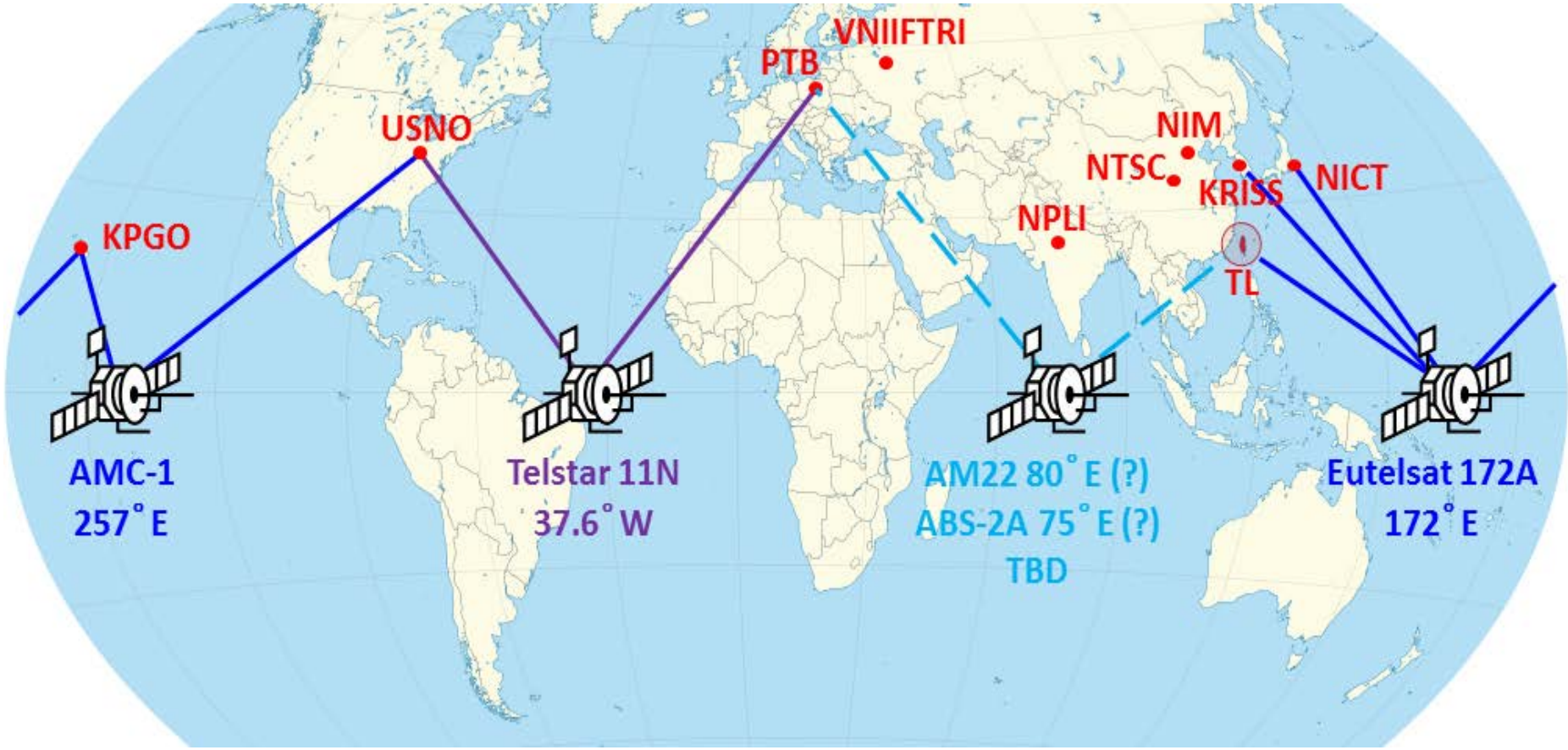
EURAMET	SIM	APMP	COOMET	AFRIMETS	GOLFMET
AOS	APL	AUS	BY	KEBS	INPL
BEV	CNM	BIRM	KS	NIS	MTC
BIM	CNMP	EKO	SU	SA	SASO
CAO	IGNA	JATC	UA		
CH	INTI	KIM			
DLR	INXE	KRIS			
DMDM	NIST	MSL			
DTAG	NRC	NAO			
EIM	NRL	NICT			
ESTC	ONBA	NIM			
IFAG	ONRJ	NIMT			
IPQ	TCC	NMIJ			
IT	USNO	NMLS			
JV		NPLI			
LT		NTSC			
MIKE		SCL			
MKEH		SG			
NIMB		TL			
NPL		VMI			
OP					
VSL					

Table 1. Group 1 (red) and Group 2 (black) UTC contributing laboratories in the RMOs (as in April 2014)

- **TL is one of the Group-1 Labs in APMP**
- **Participated in BIPM Group-1 GPS calibration trip (Phase 1, March-September 2016), BIPM – TL – NICT – NIM – BIPM**
- **Host Group-2 calibration campaign (February - May 2017, MEDEA ILC project) TL – NMIT – NMIM – VMI – TL**

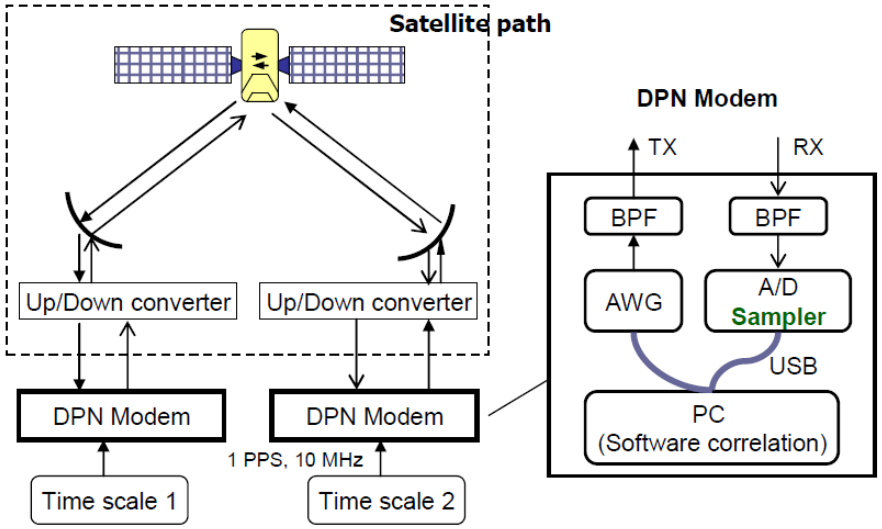
中華電信

Time and Frequency Transfer -- TWSTFT

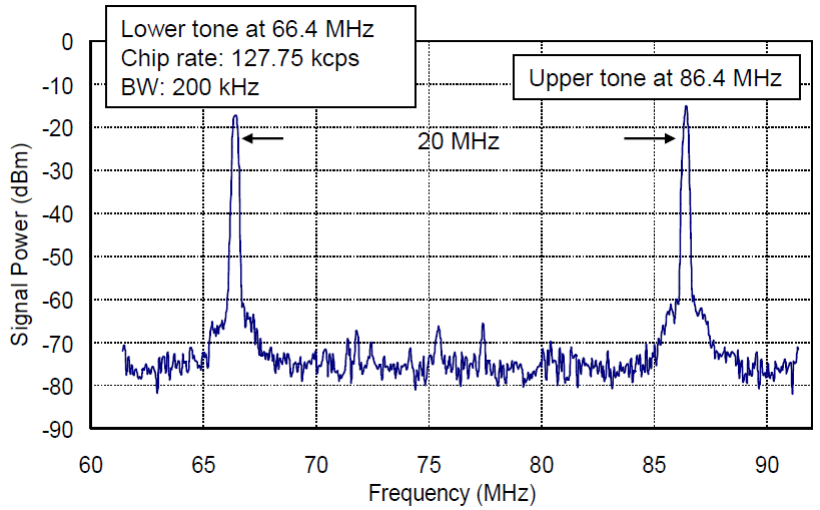


- TL has been devoted to the TWSTFT activities since 2002, and established the first Europe-Asia (VSL-TL) link in 2003.
- TL still maintains four earth stations for the TWSTFT experiments:
  Asia-Pacific link、Europe-Asia link, and North America-Asia link

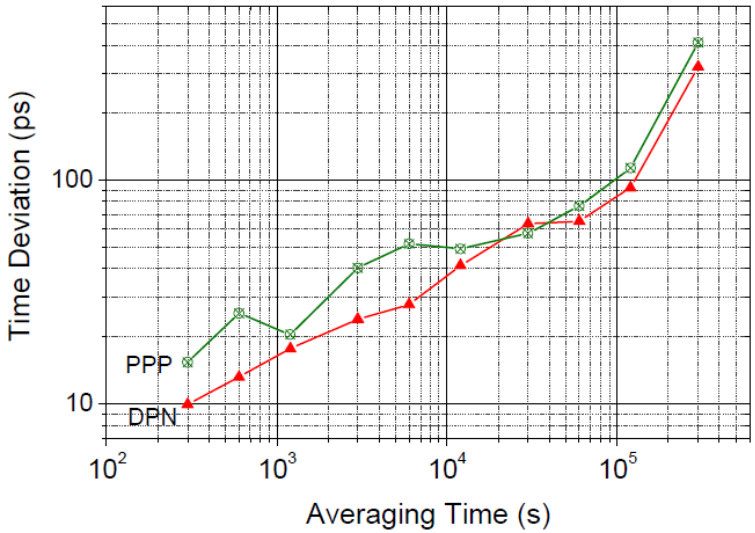
Two-Way Satellite Time and Frequency Transfer Experiment using Dual Pseudo-Random Noise (DPN) Codes



a DPN-based TWSTFT system.



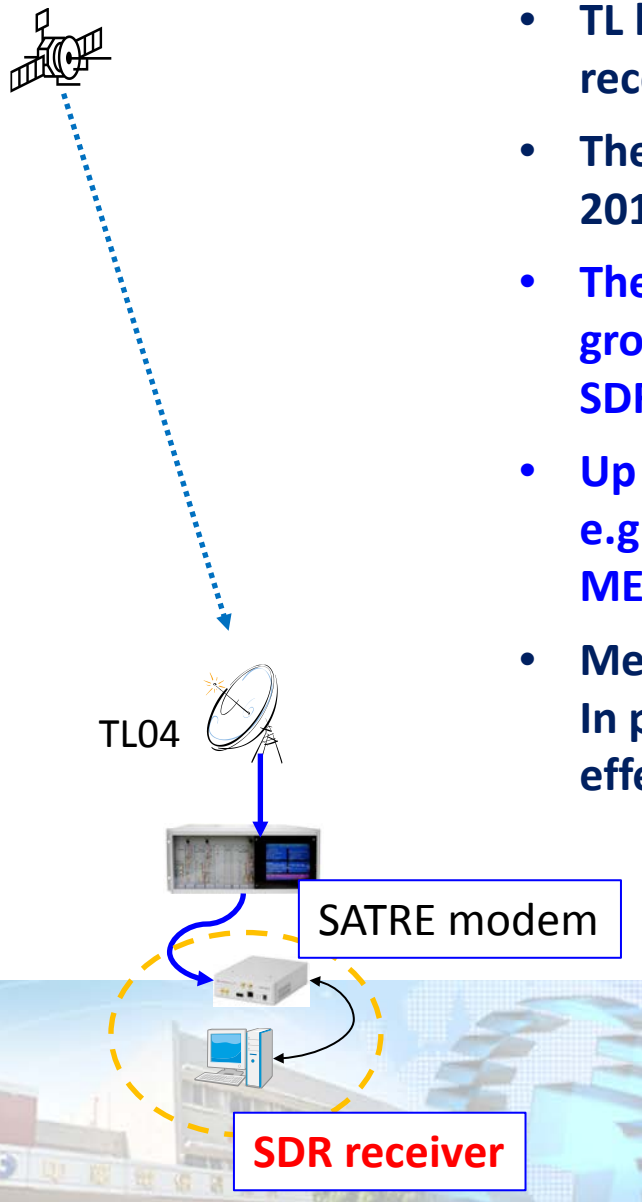
Two narrow PRN coded signals are separated by 20 MHz



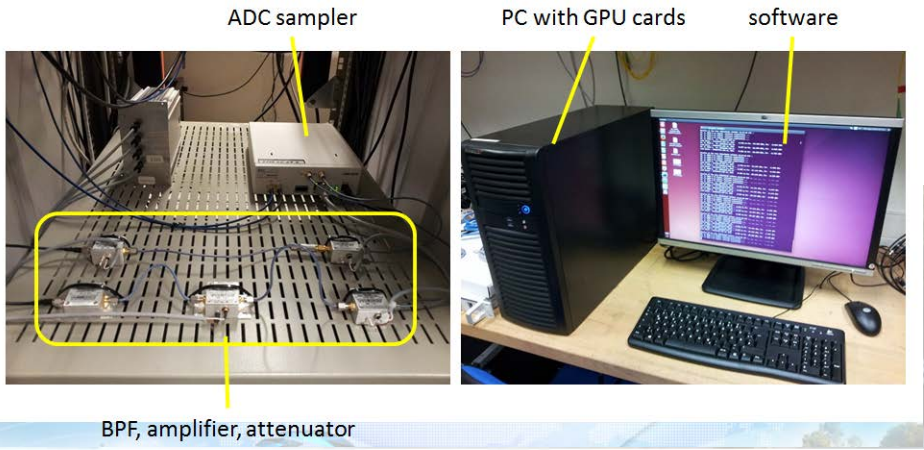
TDEV comparison between DPN and GPS PPP for the NICT-TL link

- **Cooperation between NICT and TL in 2010**
- **the performance of DPN Results is as good as the GPS PPP results.**

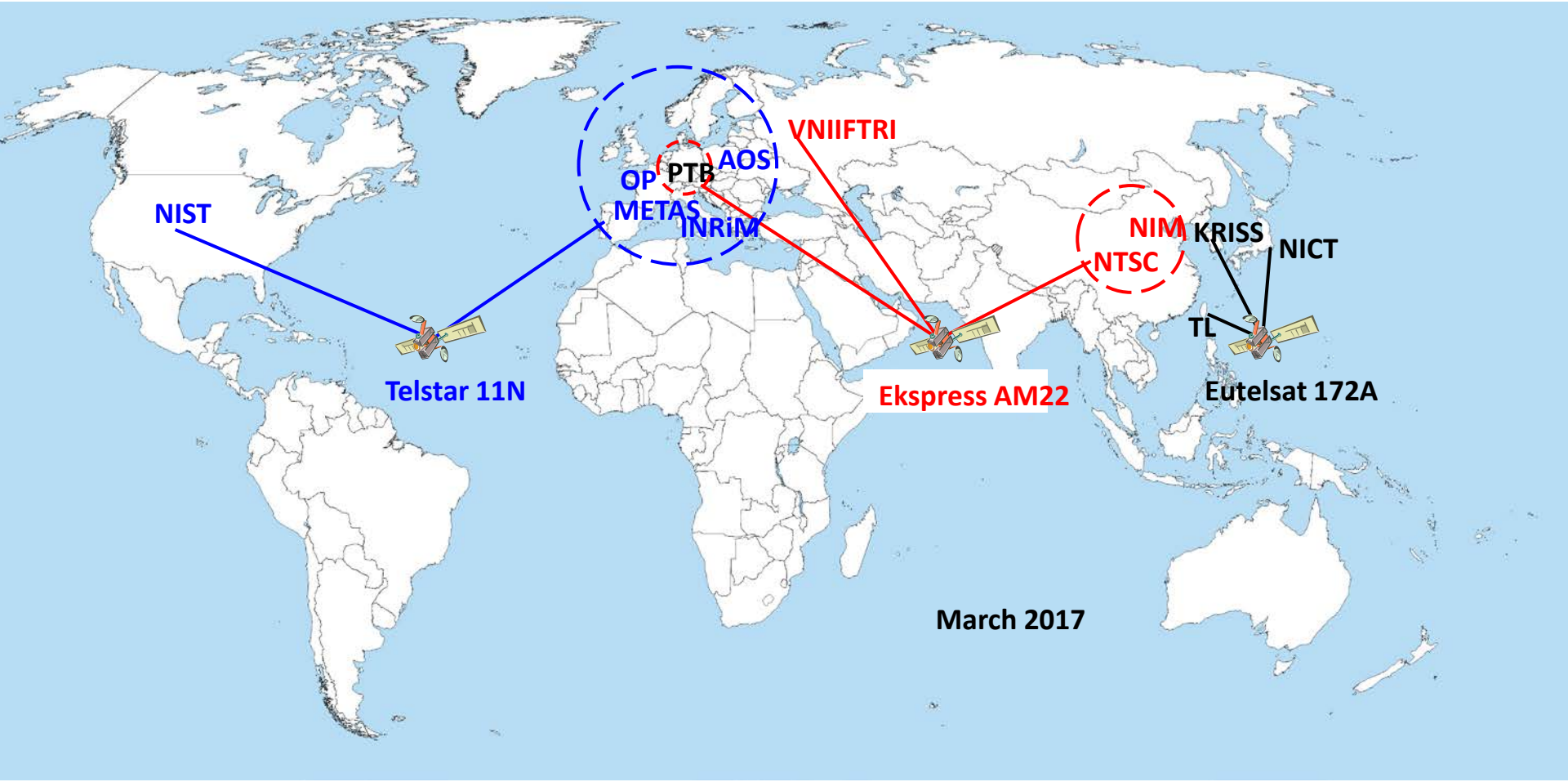
TWSTFT Software Defined-Radio (SDR) Receiver



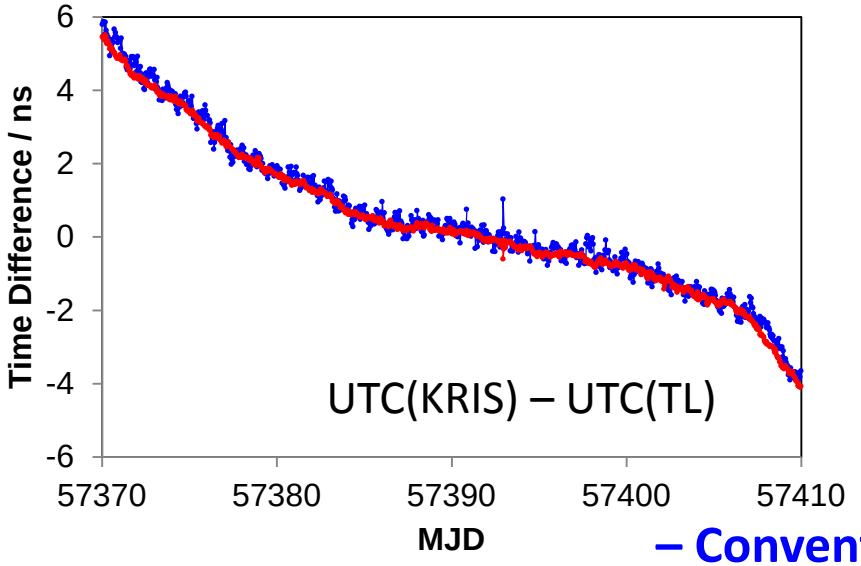
- TL has been devoted to the development of TWSTFT SDR receiver since 2014.
- The preliminary SDR experiments among TL, NICT and KRISS in 2015 showed good results.
- The BIPM and CCTF WG on TWSTFT established a pilot study group (PSG) in 2016, to evaluate the feasibility of contributing SDR technology to UTC generation
- Up to now, the SDR receivers have been installed in many Labs, e.g., PTB, OP, NTSC, NIST, NIM, VNIIFTRI, INRiM, AOS, and METAS, … etc .
- Measurement results using SDR receivers show good stability. In particular, the diurnal phenomenon in several links was effectively reduced

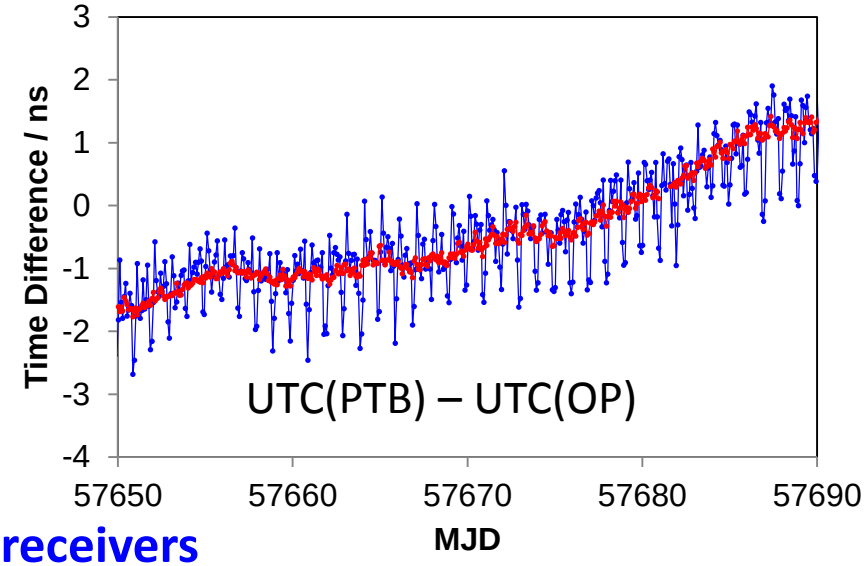


Pilot Study on applying SDR technology to UTC generation



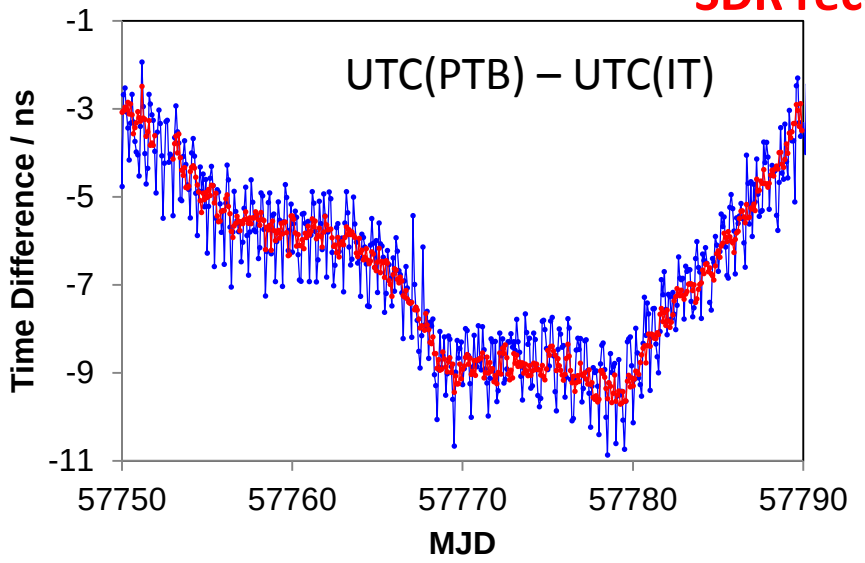
Comparison of TWSTFT results by using Conventional and SDR receiver

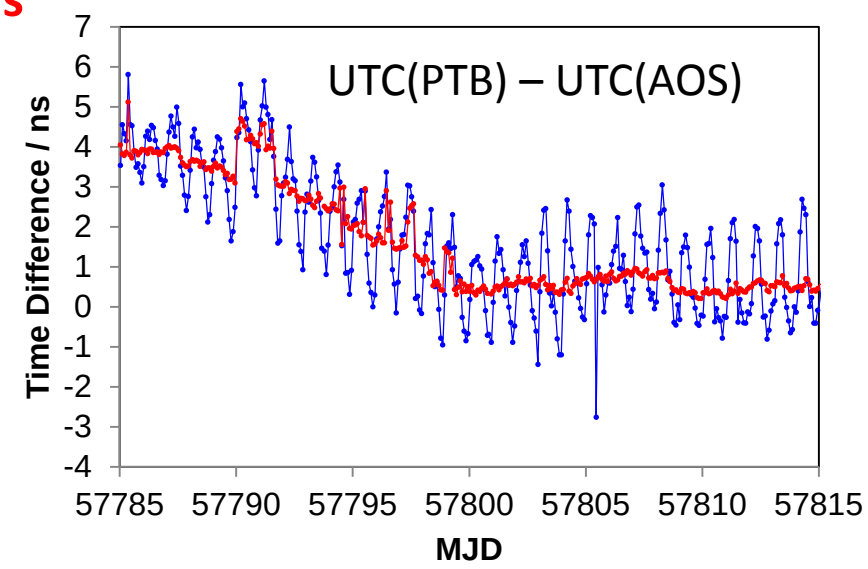




– Conventional receivers

– SDR receivers

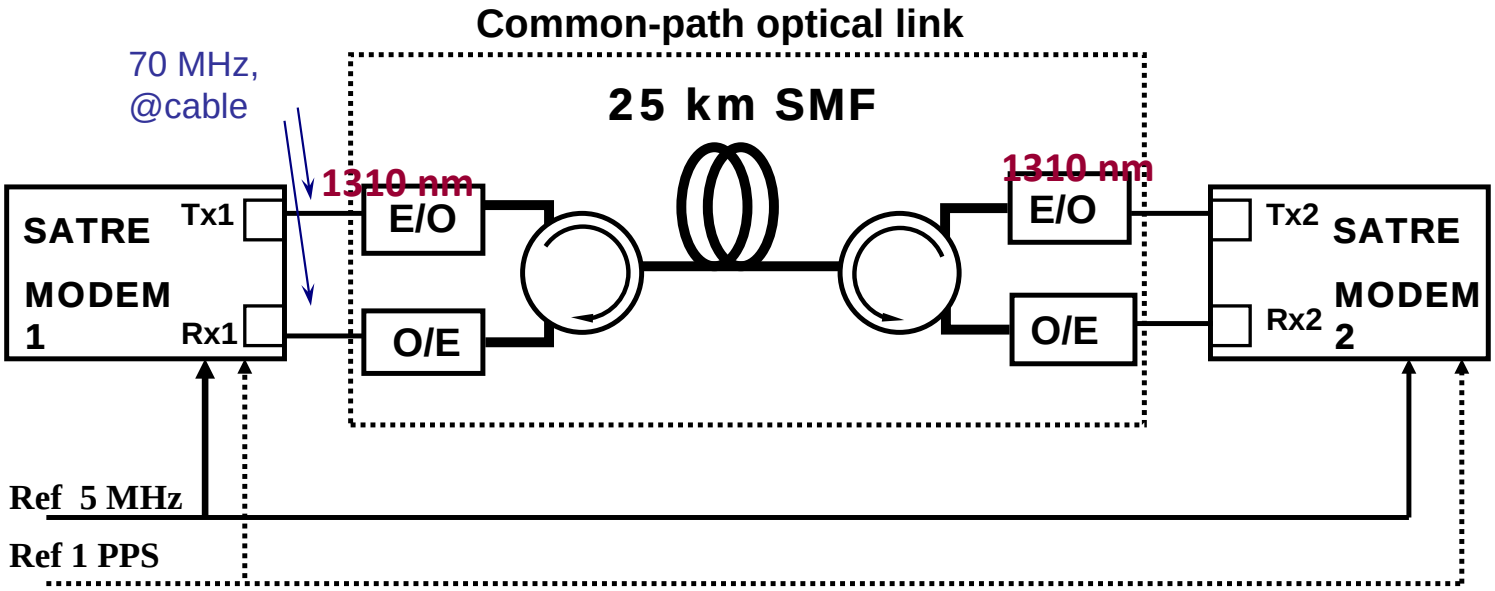




Time transfer via optical fiber

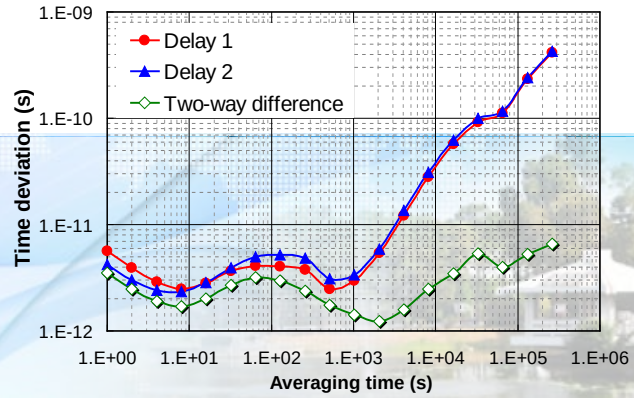
TW time transfer experiment through a **common-path optical fiber link**

- provide good reciprocity in both directions
- common clock test through 25-km long spool of fiber

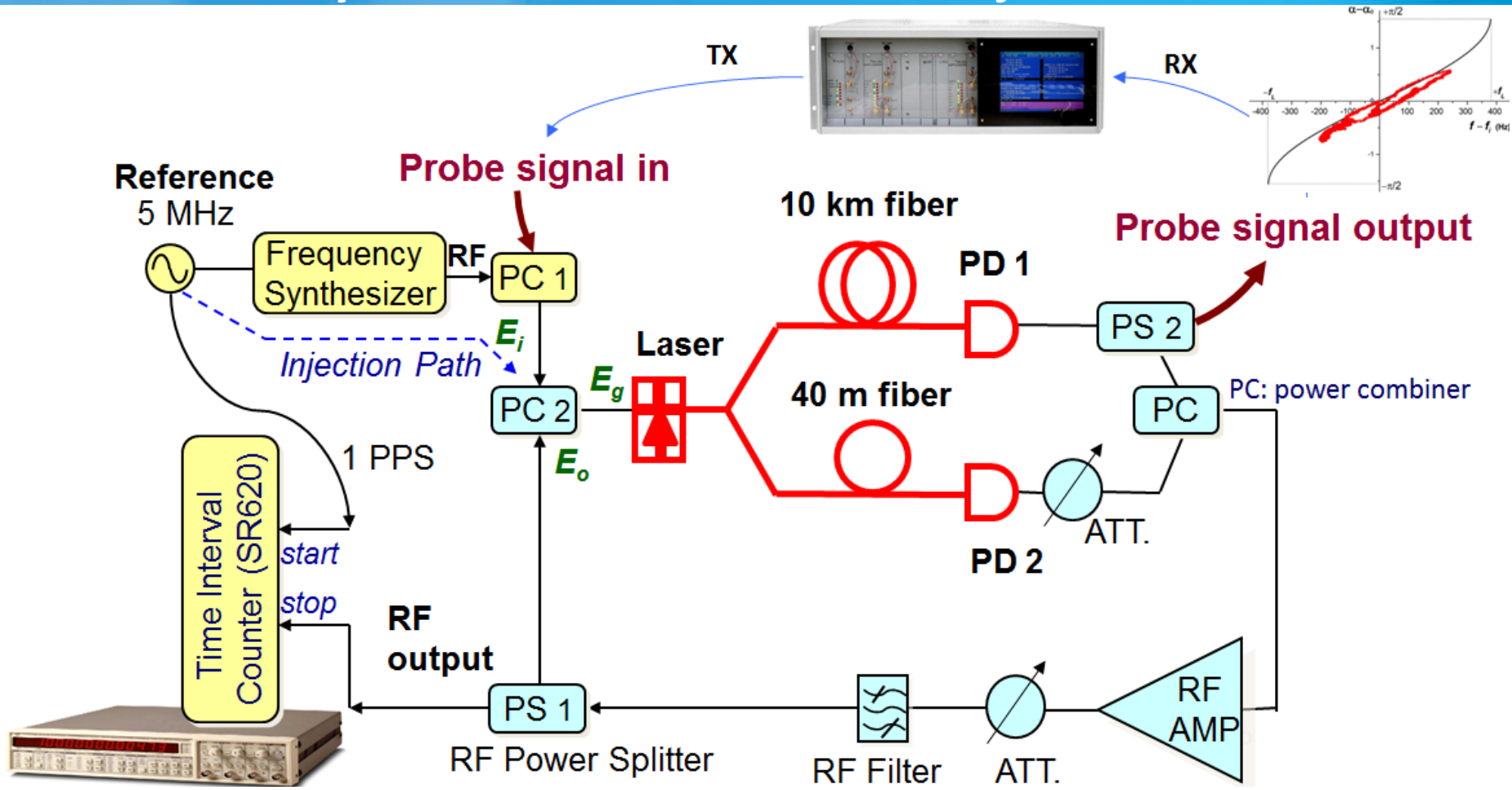


Time deviation (TDEV): 7 ps

frequency stability : 2E-16 (@ 1 day)



Other Researches:
Fiber delay fluctuation on reference injection-locked OEO



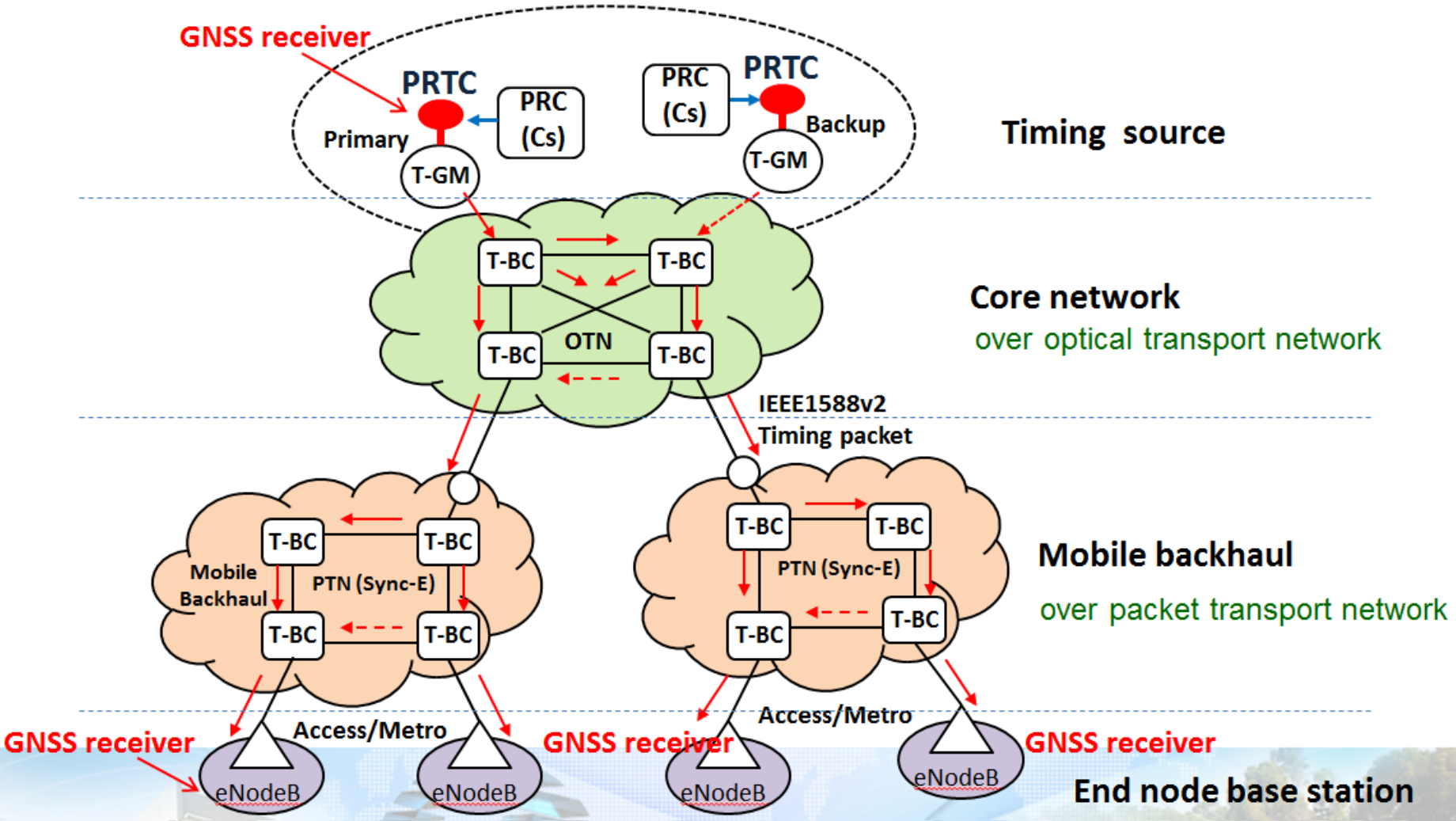
We have proposed a structure of OEO, based on optical fiber loops to act as a high-Q cavity, which can generate stable radio-frequencies (RF) signal.

- TIC was used to detect the time shifts between OEO output & the reference.
- TWSTFT modem was used to monitor the fiber delay.

OEO: OptoElectronic Oscillator

Timing distribution for Mobile networks

-Primary reference time clock (PRTC) provides the reference time to T-GM



The performance of time transfer through a mobile backhaul network was evaluated. With the support of IEEE 1588 v2 packets and Sync-E, very stable results were obtained. The accuracy of time transfer experiment is about of 100 ns.

Microwave Frequency Measurement Capability

- The range of microwave frequency calibration at TL using a down-convert technique : 300 MHz ~ 26.5 GHz
- An active microwave amplifier doubler has been used to extend the upper limit of our system from 26.5 GHz to 40 GHz since 2014
- By using TL's system, the frequency stability of the common clock test is about 3.0E-13 (carrier frequency 40 GHz ; τ = 1 sec)

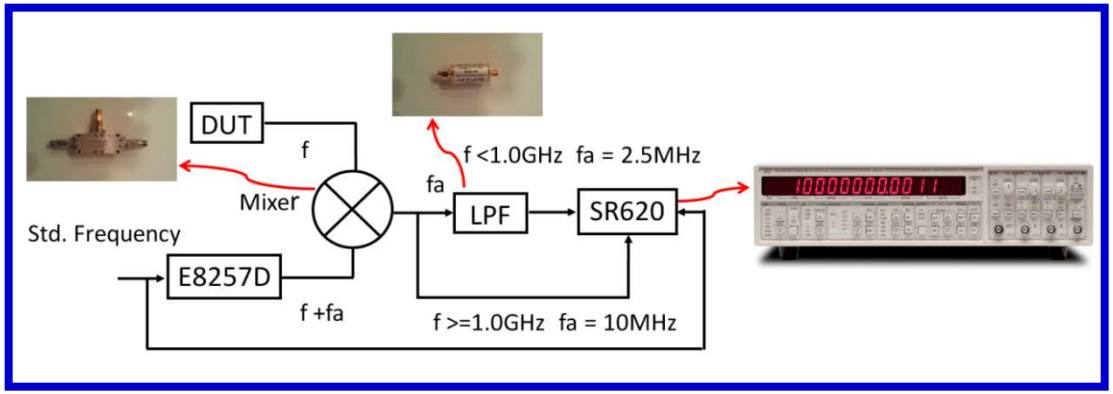
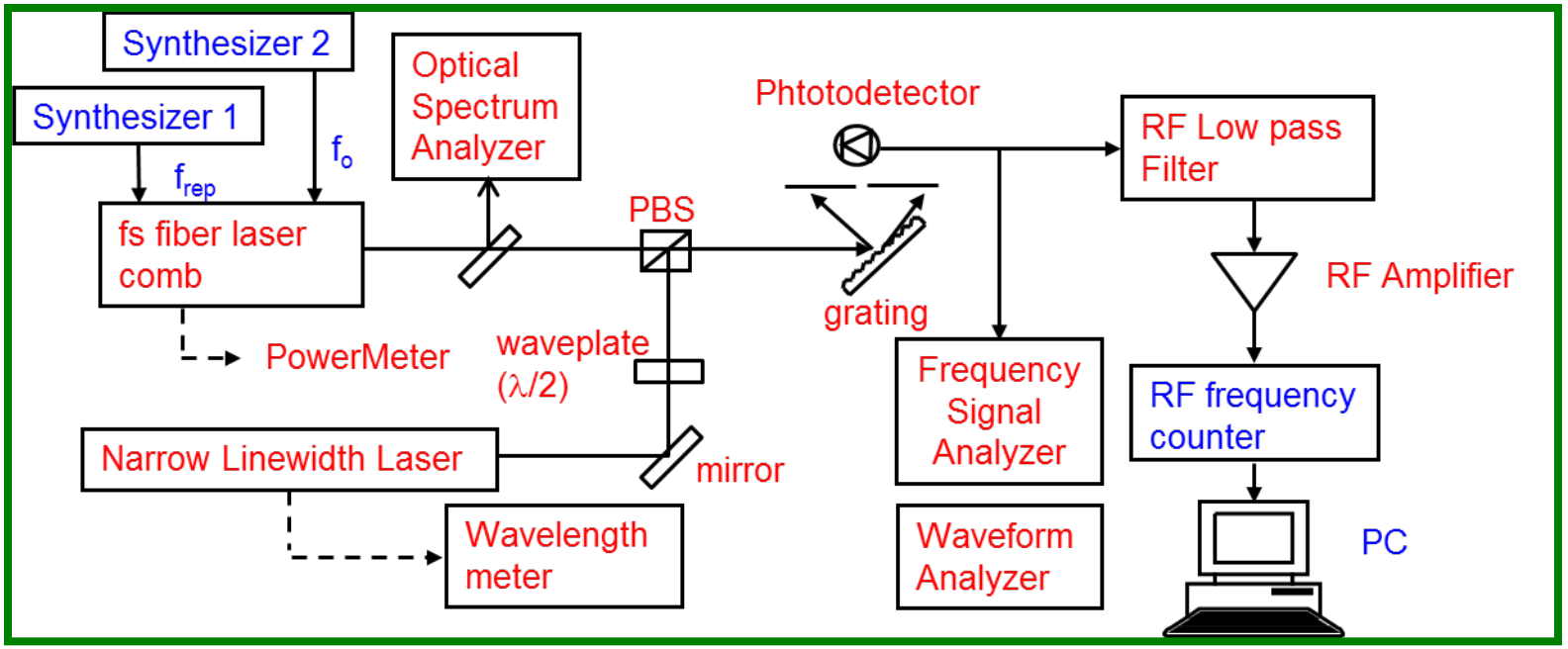


Fig 1. Diagram of the microwave frequency measurement at TL using a down-convert technique

Fig 2. An active microwave amplifier doubler and a power supply

Optical Frequency Measurement

- Since the end of 2015, TL has extended its frequency measurement capability from microwave (~40 GHz) to optical (1100~2200 nm, or 136~272 THz) field based on the fiber laser comb technology.



➢ Diagram of the optical frequency measurement setup at TL

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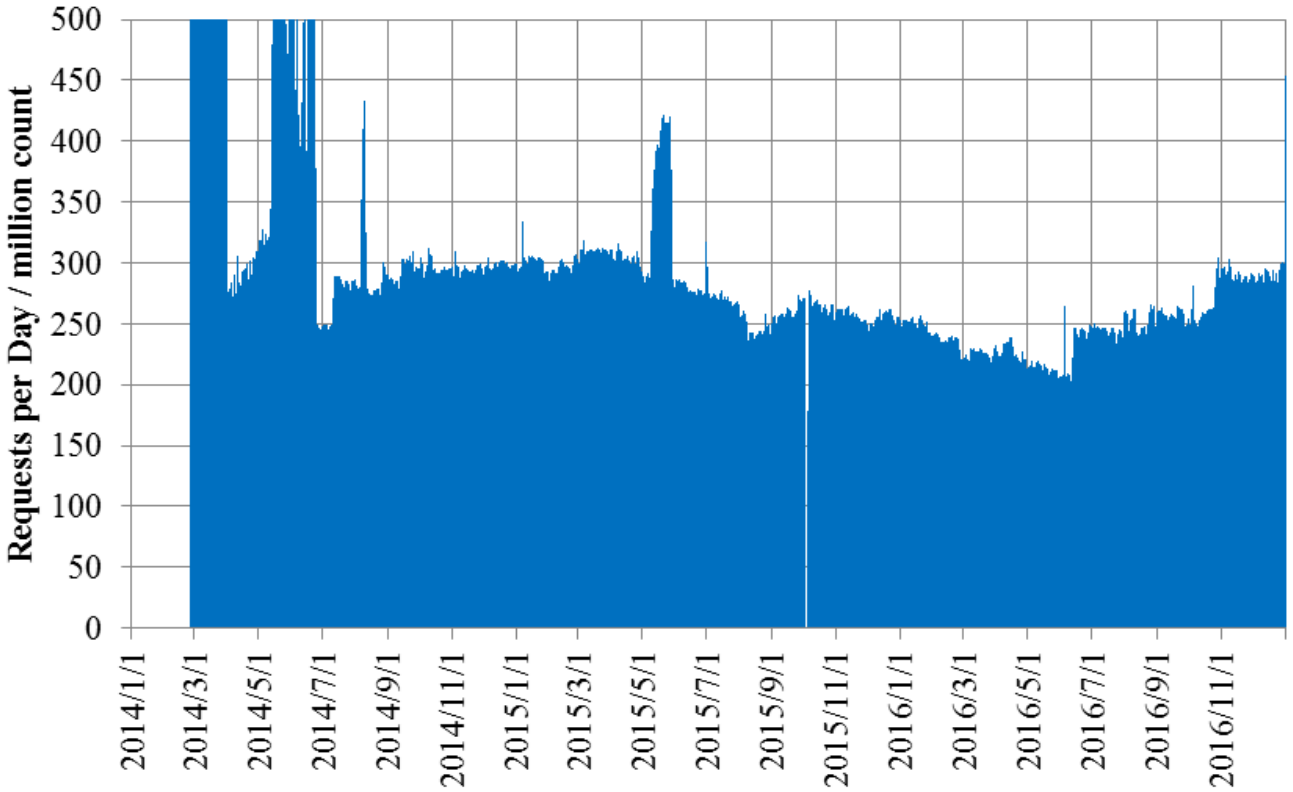
Dissemination: NTP (Network Time Protocol)

- **NTP is the major time dissemination service of TL.**
- **TL has provided this time synchronization service though Internet since June 1998.**
- **In 2014, TL renewed its monitoring system to maintain the NTP services and record the request counts. The amount of NTP requests is more than two hundred million per day.**



- The request count of the NTP service from 2014 to 2016

Dissemination: Robust Speaking Clock Design

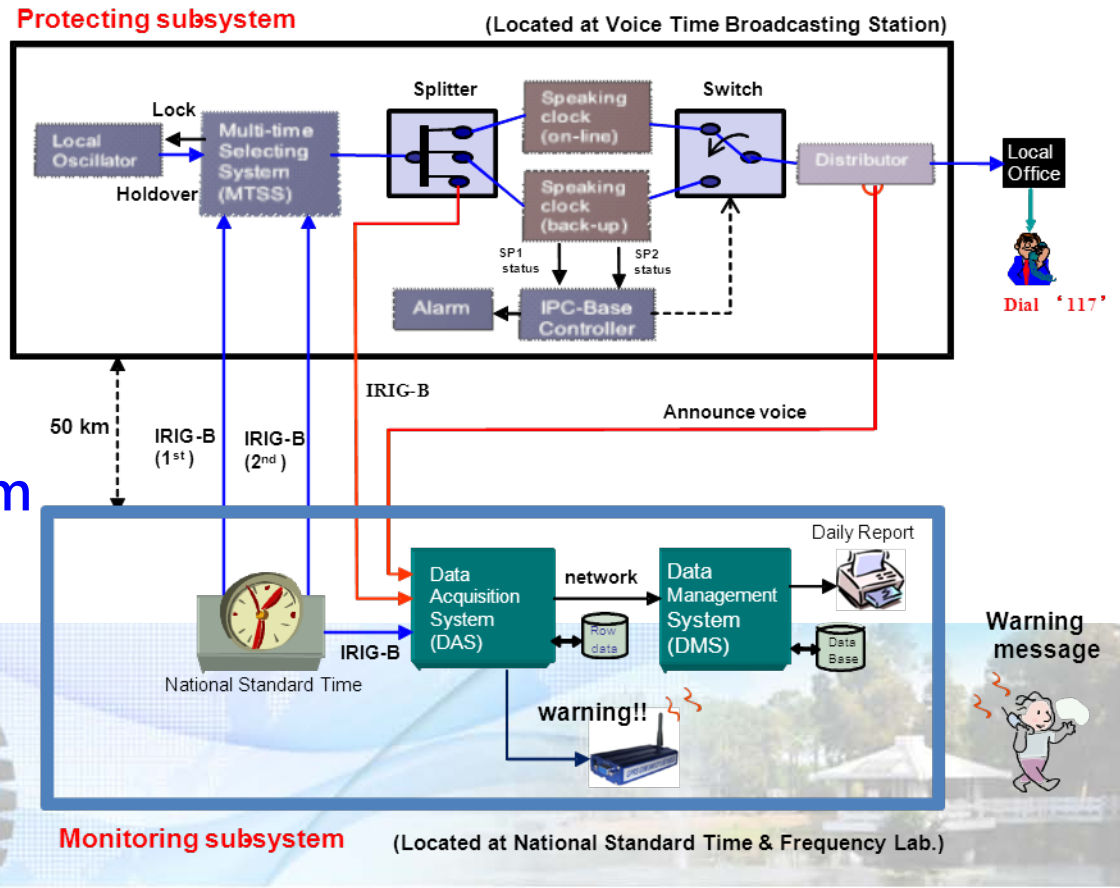
- TL has provided “117 speaking clock” service for more than 50 years, and the old system was replaced by an IPC-based digital system since 1994.
- The amount of speaking clock service is hundreds of thousands per day.
- Recently, a supporting system with protection and monitoring functions were developed to make the service running smoothly and reliably.

the protecting sub-system

- The sub-system with multi-time selecting and back up functions was designed to prevent any possible failure.

the monitoring sub-system

- Measure the input and output time error.
- Warning message alert operator in case an error happens.



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International cooperation activities:

Actively participated in the CCTF relative activities

CCTF TAI contribution labs

CCTF WG on MRA

CCTF WG on GNSS

CCTF WG on TWSTFT

CCTF WG on ATFT

International workshops, training activities

TL is full member of APMP, and has actively participated in the TCTF activities

- **Support the intra- and inter- RMO CMCs reviews for APMP WGMRA**
- **Since 2011:**
  invited by KRISS, NICT, NMIJ, NIM, NMIM, RCM-LIPI as Peer reviewer

Workshops and Training activities:

2012 APMP TC initiative project – GPS calibration Exercise

2013 host **ATF workshop** (as joint sessions of **AP-RASC'13 Conference**)

2013 host **2013 APMP GA and TCTF meeting**

2014 host **ATF workshop** (join with **IEEE IFCS** as a technical co-cosponsor)

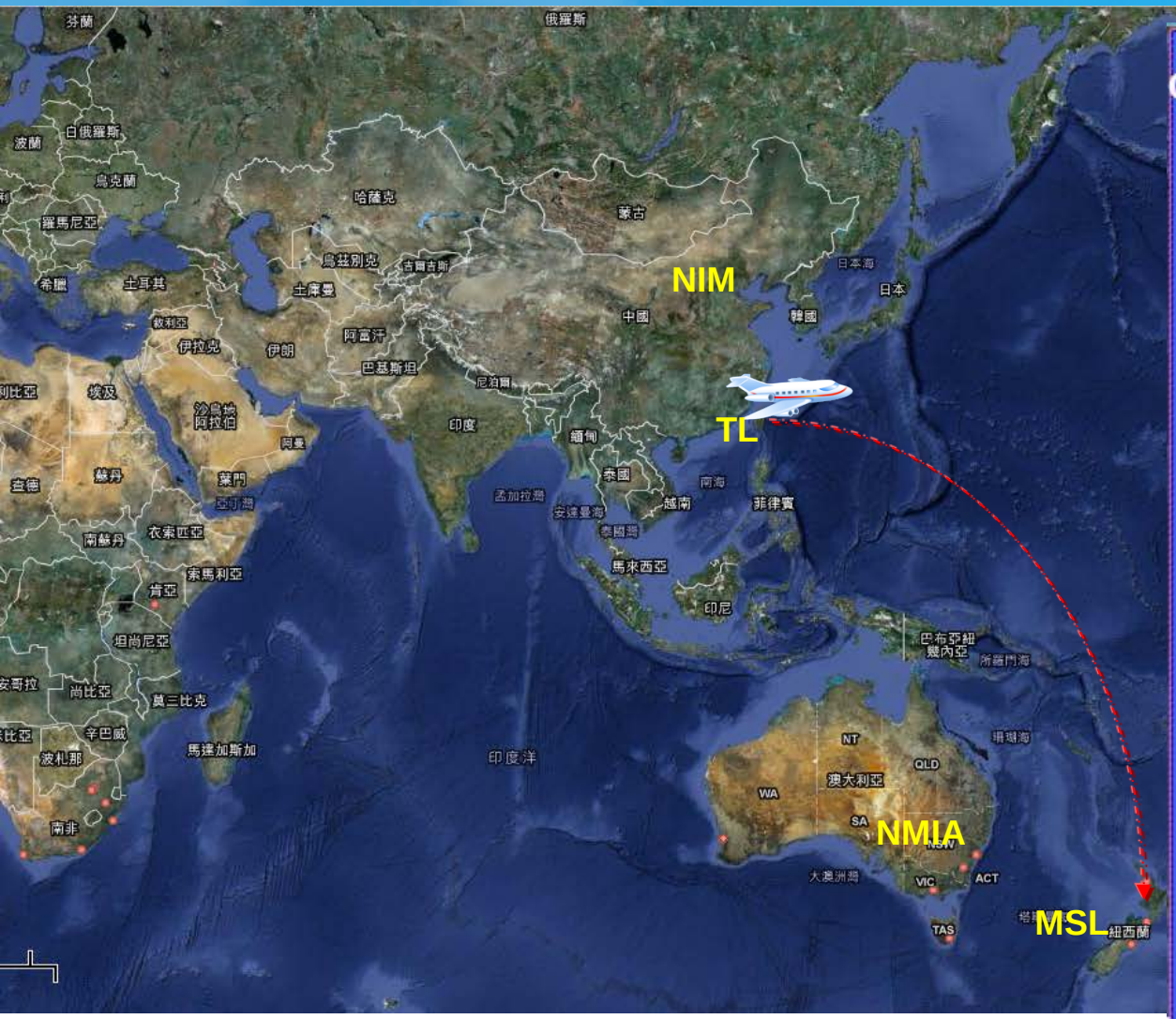
2014 proposed MEDEA workshop on Participating in UTC (host by NIM)

2016 host MEDEA kickoff workshop on GPS time transfer and calibration techniques

2017 **GPS Inter-Laboratory Comparison** (ILS) – G2 calibration campaign (MEDEA)
Expert Site-Visit, and **Concluding Workshop** (MEDEA)

* **MEDEA (Metrology-Enabling Developing Economies in Asia) : funding support by PTB**

TC Initiative-2012-04-TCTF

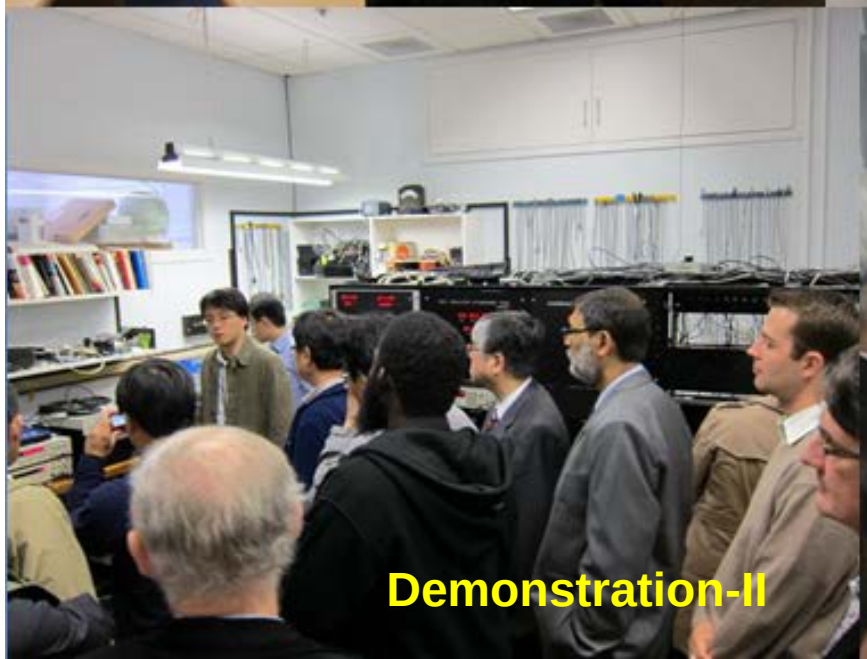


GPS receiver calibration system x 2

- GNSS receiver
- Antenna
- Antenna cable
- Personal Computer
- Time Interval Counter
- Aluminium Tripod

中華電信 Refresh your life

TC Initiative-2012-04-TCTF



The ATF 2013 Workshop

- **The ATF 2013 workshop was held as the joint sessions of commission-A in the AP-RASC'13 Conference**

General Information
- Phtoto Gallery
- Scope & Welcome
- Committees
- Sessions & Conveners
- Sponsorship
- Important Dates

Technical Activities
- Program
- Information for Session Presenters
- General Lectures
- SPC Special Session
- Student Paper Competition (SPC) Finalists List
- Young Scientist Award (YSA) Recipients List
- 2nd Call for Papers
- 1st Call for Papers
- Student Paper Competition (SP...
- Young Scientist Award (YSA)
- Paper Submission

- **Sept. 3-6 ATF 2013 Workshop**
- **60 papers ~**
  - 2 Plenary sessions, 8 Oral sessions, and one poster session
- **Sept. 5-6 CCTF WG on TWSTFT meeting**

Assemblies and Scientific Symposia. The objective of the AP-RASC is to review current research trends, present new discoveries, and make plans for future research and special projects in all areas of radio science, especially where international cooperation is desirable, and a particular emphasis is placed on promoting various research activities in the Asia-Pacific area.

Scientific sessions composed of oral and poster papers will be organized at this conference in order to cover all scientific activities by URSI Commissions A-K:

A. Electromagnetic Metrology

B. Fields and Waves

C. Radio Communication Systems and Signal Processing

D. Electronics and Photonics

Photos of the AP-RASC'13 Conference

2013 APMP GA and TCTF meeting

2013 APMP TCTF meeting in Taipei

General Chair:
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Local Organizing Committee Chair:
Sheng-Shian Li

Authors are invited to submit abstracts covering recent and original work of interest to the frequency control community in the topics listed below. The 2014 Symposium aims to highlight manufacturing methods and technologies that realize emerging products in MEMS resonator-based devices, quartz micro-clocks, and advanced atomic frequency standards, so contributions in these areas are encouraged.

The ATF 2014 workshop is a technical co-sponsor of the symposium, so members of the APMP (Asia Pacific Metrology Programme), TCTF (Technical Committee on Time and Frequency), and NMIs (National Measurement Institute) are also encouraged to submit abstracts. Paper selection and publication will follow past rules established by IEEE and the IFCS.

The ATF 2014 workshop is a technical co-sponsor of the symposium, so members of the APMP (Asia Pacific Metrology Programme), TCTF (Technical Committee on Time and Frequency), and NMIs (National Measurement Institute) are also encouraged to submit abstracts. Paper selection and publication will follow past rules established by IEEE and the IFCS.

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Important Dates:

Abstract Submission Deadline:
January 10, 2014

Acceptance Notifications:
February 20, 2014

Final Paper Submission Deadline:
March 28, 2014

Group 6: Optical Frequency Standards and Applications
A. Optical Ion and Neutral Atom Clocks
B. Optical Frequency Combs and Frequency Measurements
C. Ultra-stable Laser Sources and Optical Frequency Distribution
D. Ultra-stable Optical to Microwave Conversion

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2014 Workshop on Participating in UTC (MEDEA project)

- **Two-day workshop proposed by TL as a MEDEA project, and was held by NIM on 5-6 Nov., 2014**
- **MEDEA Workshop on "Participating in UTC"**
  - ✓ To equip participants with the technical knowledge to participate in UTC
  - ✓ To hear what the needs of the participants are and inform further projects within the DEC

2016~ 2017 MEDEA project
"GPS time transfer and calibration techniques training activities"

- A series of training activities in **GPS time transfer and calibration techniques** were organized by TL in 2016-2017, to support the NMIs of APMP Developing Economies.
- Training activities included **a kickoff workshop, inter-laboratory comparison (ILC), and site visits by experts** in the field.
- **The kickoff workshop** was held from Sept. 27-29, 2016 at TL. More than 20 delegates from 15 NMIs participated the kickoff workshop.

The group –photo of the kickoff workshop
Sept. 27-29, 2016

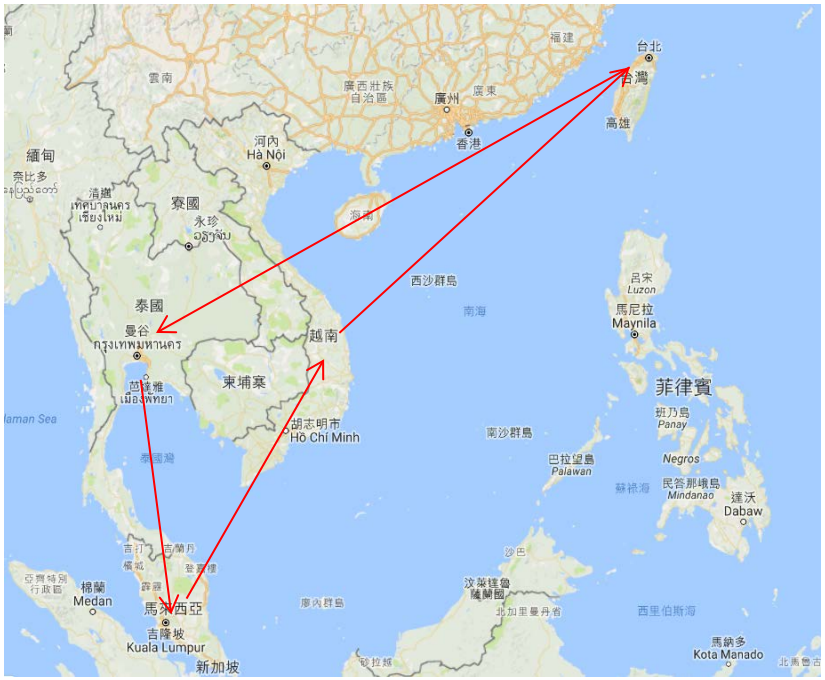
2016~ 2017 MEDEA project (~ contiune)
"GPS time transfer and calibration techniques training activities"

- **The ILC {GNSS receiver calibration campaign)** among NIMT (Thailand), NMIM(Malaysia), and VMI(Vietnam) started soon after the kickoff workshop, and the traveling system returned to TL around middle May, 2017. The ILC will be the first extended GPS receiver calibration campaign conducted within the APMP.

- **Three experts were invited to visit 3 Labs for providing on-site instructions.**

- **Concluding Workshop**

  The ILC measurement results, the lessons learned from the ILC and the achievements of the expert site-visits, will be presented in the Workshop at TL on October 25-26, 2017



~ Summary ~

- **Maintain Stable Time and Frequency standard**
  - Contribute to the generation of TAI and UTC (Ranked about 15)
  - Provide time dissemination services

- **Devote to the research of time and frequency transfer technologies**
  - One of the GPS calibration G1 Labs
  - Host the first extended GPS receiver calibration campaign within the APMP
  - TWSTFT DPN and SDR technologies

- **Actively participate in the CCTF and APMP activities**
  - Host meetings, workshops, and training activities
  - Act as a peer reviewer of many NMIs
  - Promote international cooperation

5. Publications - 1/4

Journal papers:

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13. Wen-Hung Tseng, Kai-Ming Feng, Shinn-Yan Lin, Huang-Tien Lin, Yi-Jiun Huang, and Chia-Shu Liao, "Sagnac Effect and Diurnal Correction on Two-Way Satellite Time Transfer," *IEEE Transactions on Instrumentation and Measurement*, vol. 60, no. 7, pp. 2298-2303, Jul, 2011.
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Thank You for your kind attention!