National time scale generation and distributions

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National Institute of Metrology (Thailand)
NIMT

Outline

1. NIMT time keeping and timescale generations
2. GNSS time transfers
3. NIMT time disseminations
4. Future plans
5. Conclusions

National positioning and timing infrastructure

- GNSS CORS
- Precise positioning services
- GNSS timing station by NIMT
- Timing services

NIMT time and frequency laboratory

- Realise and disseminate the SI second; UTC(NIMT)
- Contribute to the BIPM atomic time scales; International Atomic Time (TAI)
- Distributions to the public are through:
  - Calibration services: frequency standards i.e. caesium and rubidium clocks
  - Internet time services: network time protocol (NTP) and precise time protocol (PTP)
  - Fiber links: white rabbit
  - GNSS national permanent ground network: observations and correction message
- Future research works on next generation of atomic clocks based on ytterbium (Yb+) ion trap

$$1\ \mathrm{Hz} = \frac{\Delta\nu_{\mathrm{Cs}}}{9\,192\,631\,770}$$

$$1\ \mathrm{s} = \frac{9\,192\,631\,770}{\Delta\nu_{\mathrm{Cs}}}$$

1 second is the duration of 9,192,631,770 periods
of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom
https://www.bipm.org/en/si-base-units/second

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Thayathip Thongtan
United Nations/Philippines Workshop on the Applications of Global Navigation Satellite Systems
25 April 2024, Manila, Philippines

1. NIMT time keeping

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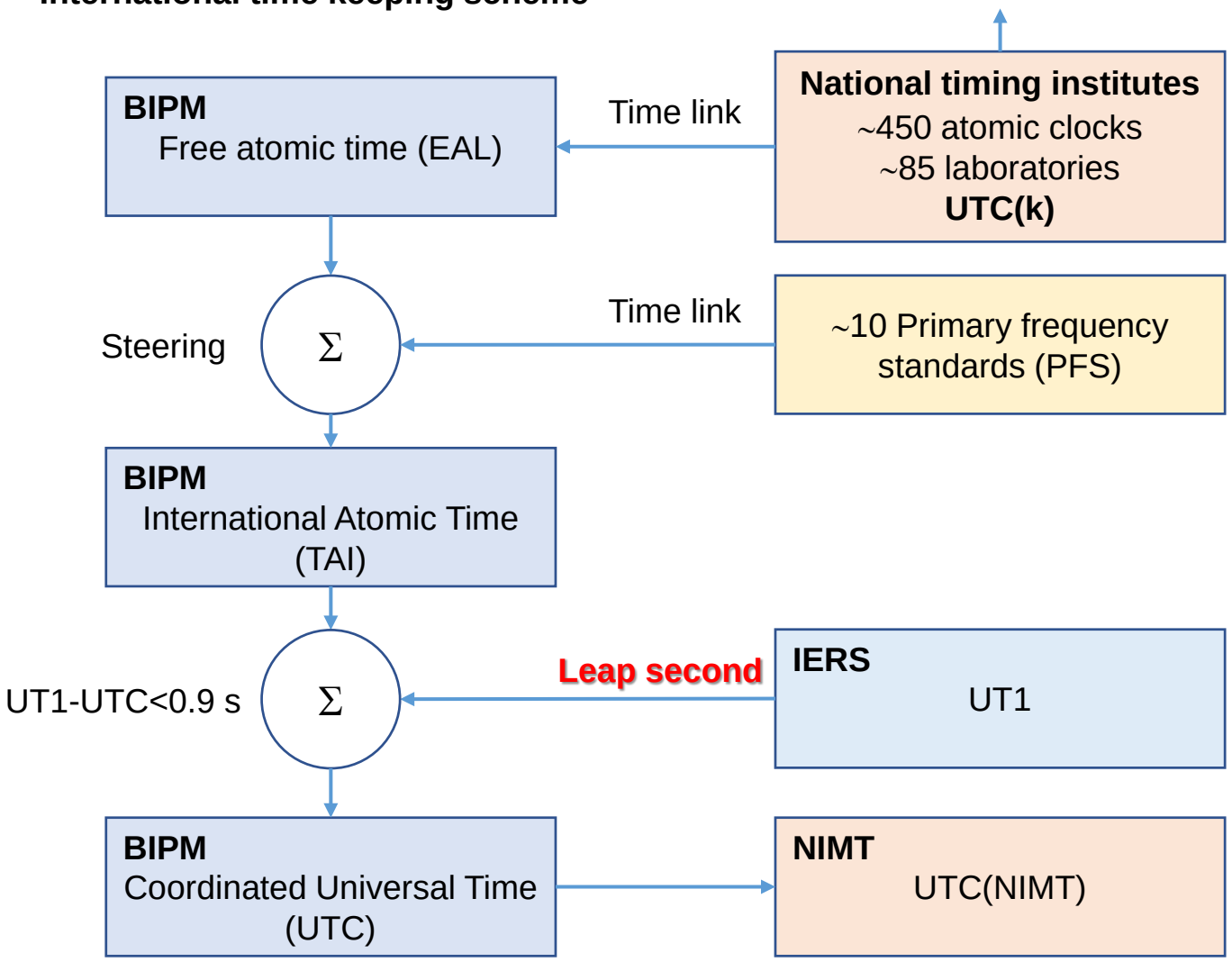
International time keeping scheme



Caesium frequency standard

Hydrogen maser

PFS

- TAI – UTC = 37 second (31 December 2016)
- 22nd CCTF meeting – hot issues are on:
  leap second in UTC,
  roadmap towards redefinitions,
  promotions of UTC and GNSS,
  international time keeping

BIPM International Bureau of Weights and Measures
IERS International Earth Rotation Services
NIMT National Institute of Metrology Thailand

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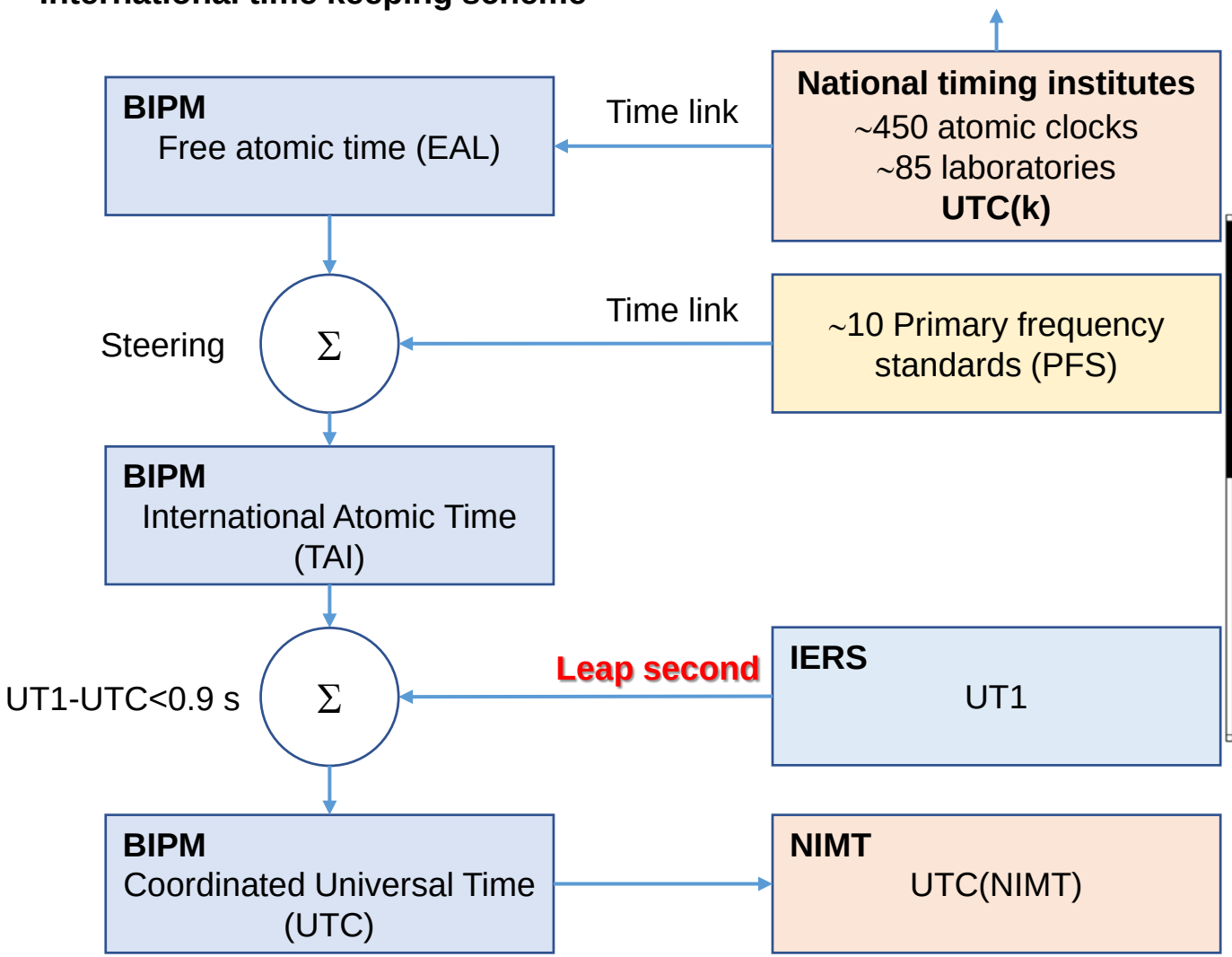
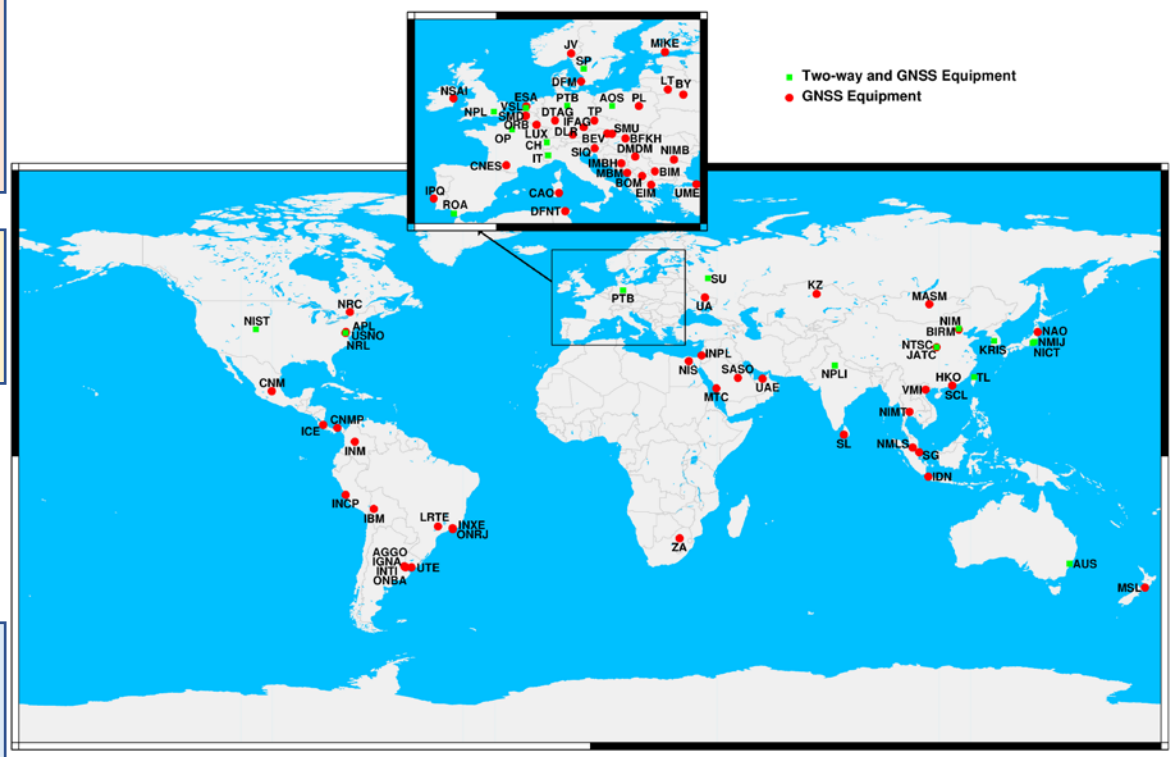


Geographical distribution of the laboratories that contribute to TAI and time transfer equipment (2023)



TAI contribution laboratories equipment:

- Two-way time and frequency transfer is via communication satellites
- **GNSS equipment**

https://webtai.bipm.org/ftp/pub/tai/other-products/maps/planisphere-2023.png

1. NIMT time keeping

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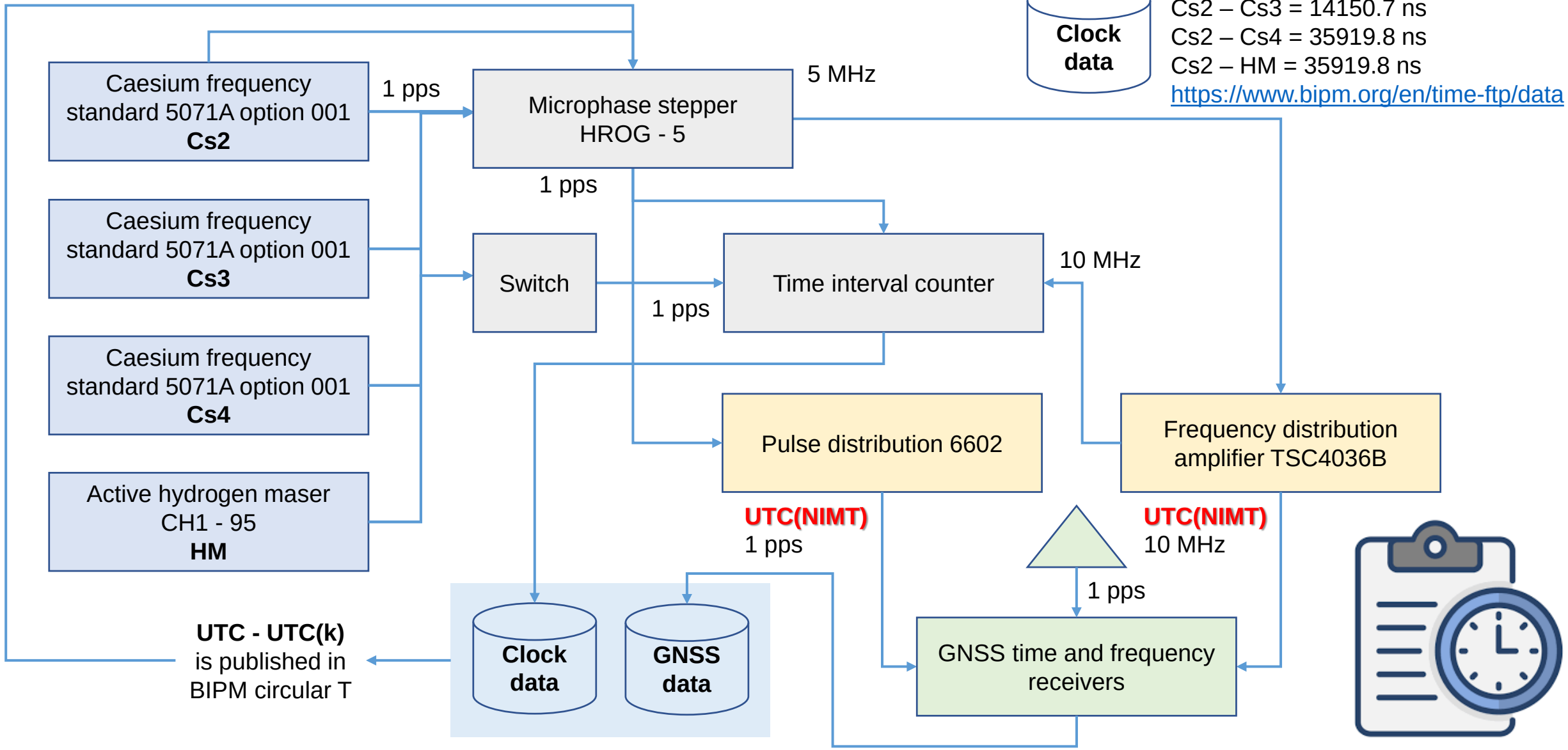
National time keeping scheme



Measured clock data: nimt2401.clk
Cs2 – Cs3 = 14150.7 ns
Cs2 – Cs4 = 35919.8 ns
Cs2 – HM = 35919.8 ns
https://www.bipm.org/en/time-ftp/data

2. GNSS time transfers

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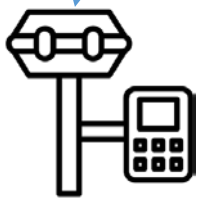
One way GNSS measurements

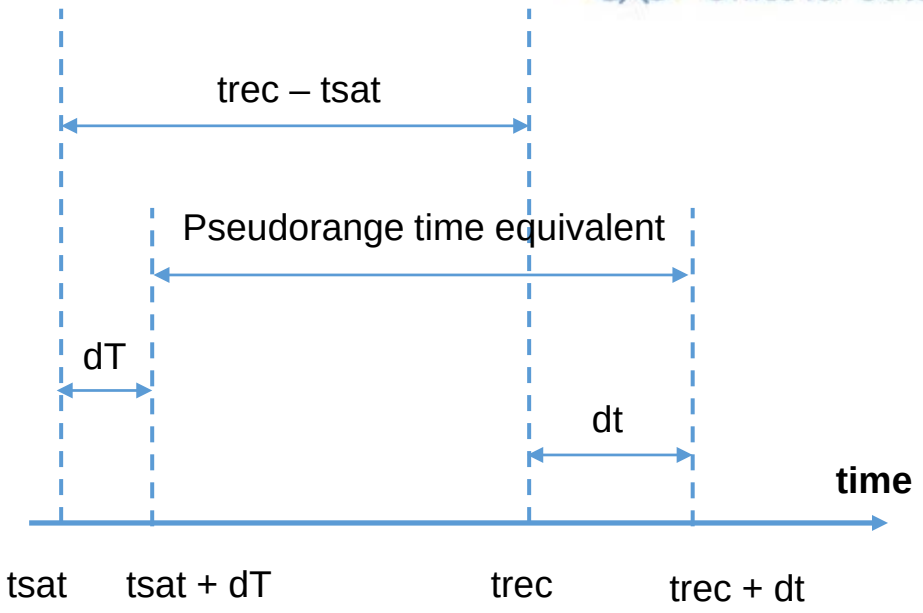
Satellite
tsat + dT

Travel time

P



Receiver
trec + dt



P = c[(trec+dt) – (tsat + dT)]

= c(trec – tsat) + c(dt – dT)

= ρ + c(dt – dT)

P = pseudorange measurement (meter)

ρ = true range (meter)

c = speed of light (meter/second)

dt – dT = receiver clock offset (second)

Example

Channel	Transmitted time (second)	Received time (second)	Travel time (ms)	Pseudorange (km)
1	500	500.067	67	20,100
2	500	500.068	68	20,400
3	500	500.077	77	23,100
4	500	500.095	95	28,500

2. GNSS time transfers

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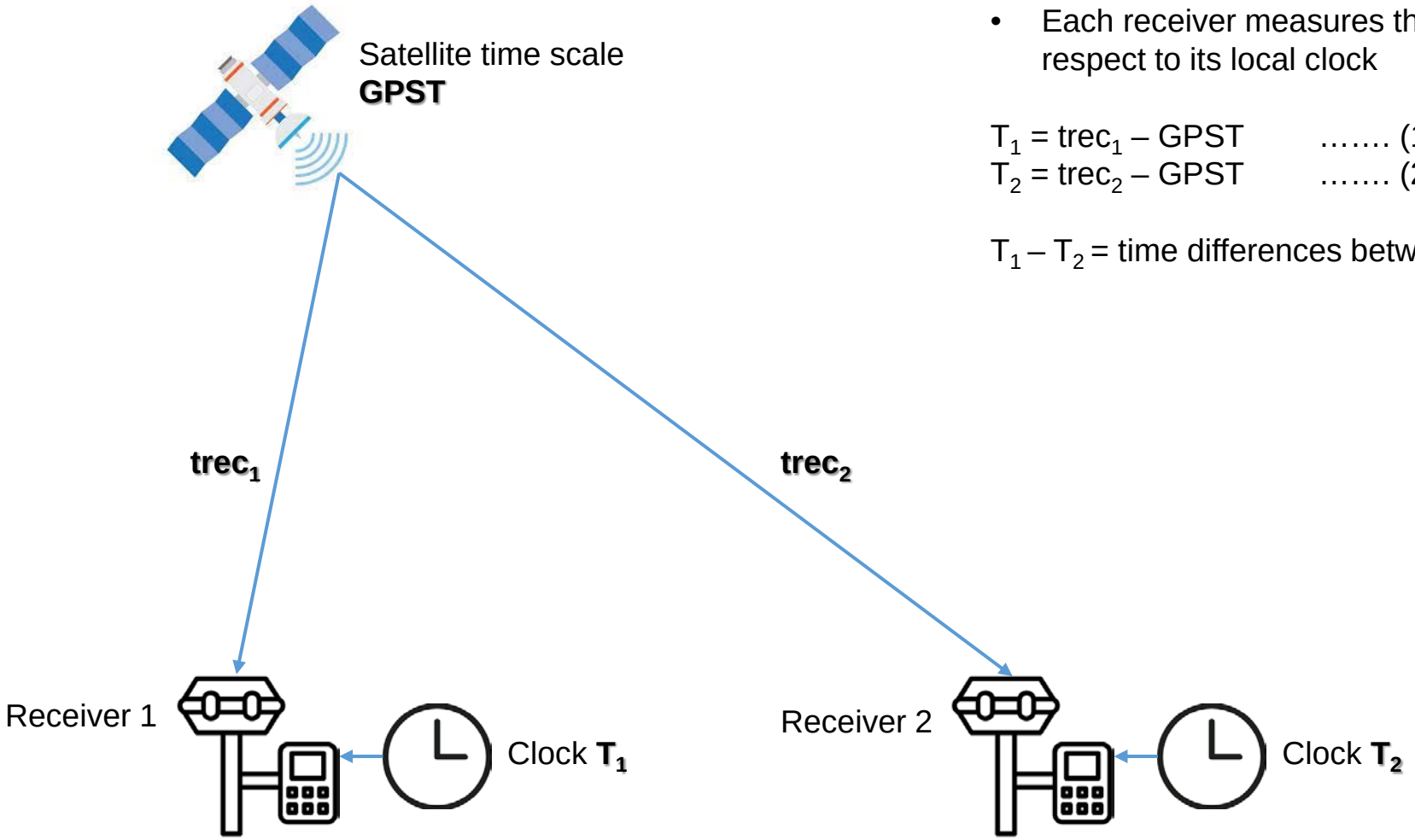
GNSS common – view measurements



- Two or more receivers observe a single physical source at the same time
- Each receiver measures the arrival time of the signal from the source with respect to its local clock

$T_1 = trec_1 - GPST$ ……. (1)
$T_2 = trec_2 - GPST$ ……. (2)

$T_1 - T_2$ = time differences between two time scales (from two different clocks)

2. GNSS time transfers

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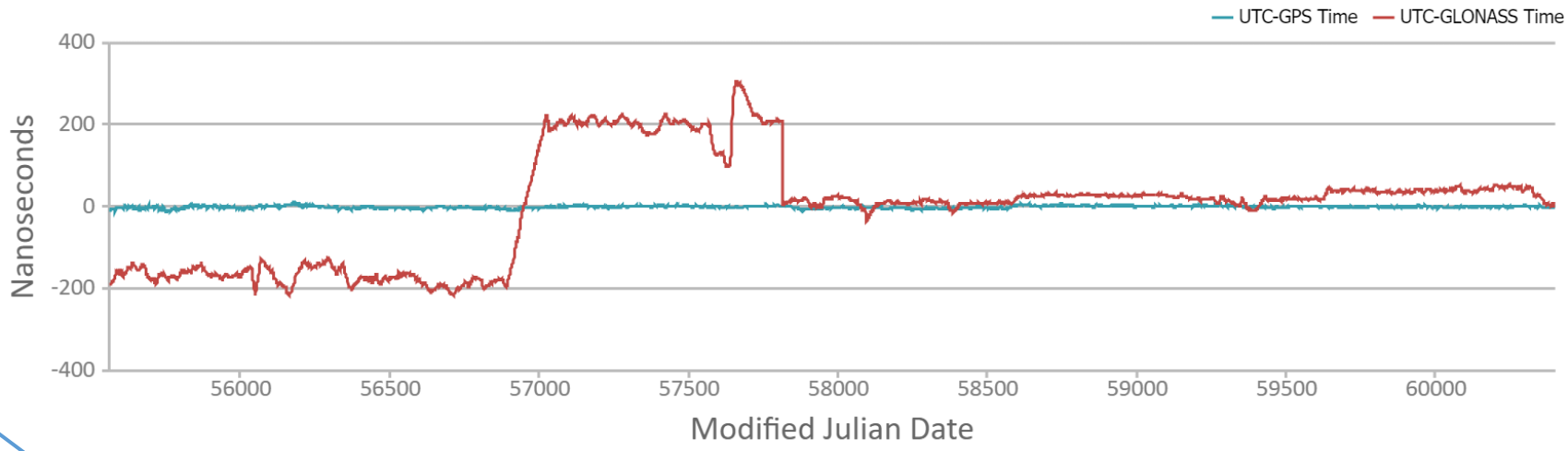
GNSS common – view measurements

Satellite time scale
GPST



$trec_1$

$trec_2$

Receiver 1

Clock T_1

Receiver 2

Clock T_2

https://webtai.bipm.org/database/canvas_gnss.html?scale=gnss&mjd1=55559&mjd2=60399

2. GNSS time transfers

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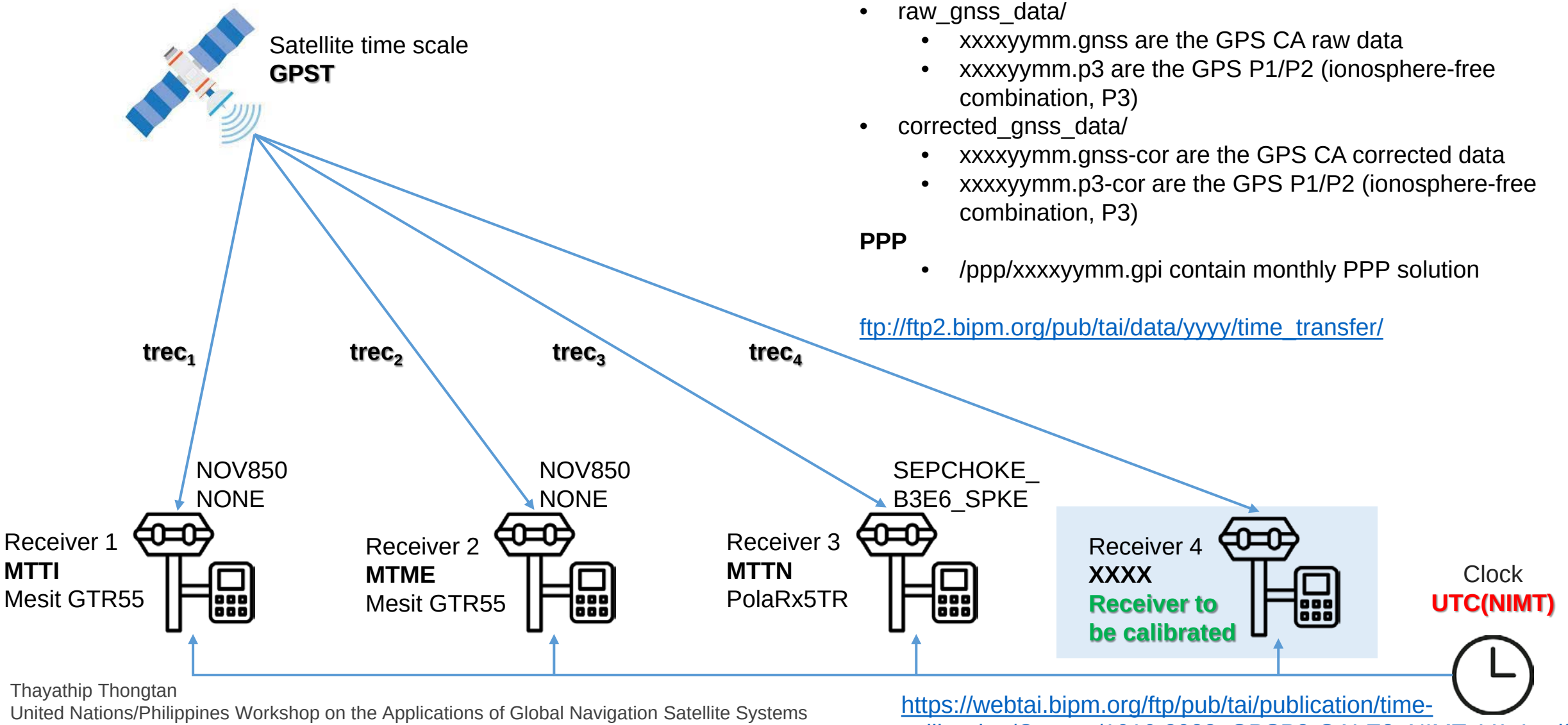
GNSS common – view measurements and common-clocks



CGGTTS

- raw_gnss_data/
  - xxxxyymm.gnss are the GPS CA raw data
  - xxxxyymm.p3 are the GPS P1/P2 (ionosphere-free combination, P3)
- corrected_gnss_data/
  - xxxxyymm.gnss-cor are the GPS CA corrected data
  - xxxxyymm.p3-cor are the GPS P1/P2 (ionosphere-free combination, P3)

PPP

- /ppp/xxxxyymm.gpi contain monthly PPP solution

ftp://ftp2.bipm.org/pub/tai/data/yyyy/time_transfer/

https://webtai.bipm.org/ftp/pub/tai/publication/time-calibration/Current/1016-2022_GPSP3-GALE3_NIMT_V1-1.pdf

2. GNSS time transfers

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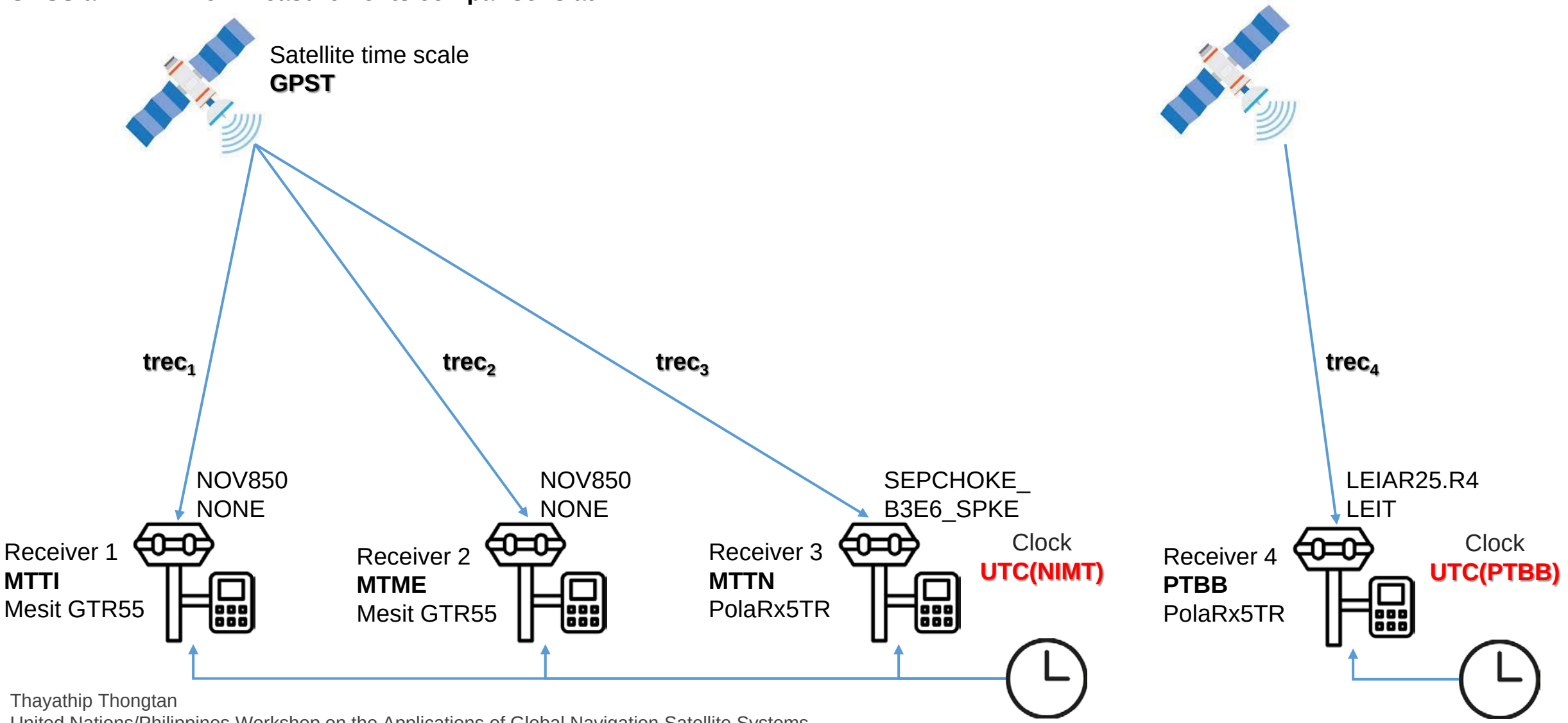
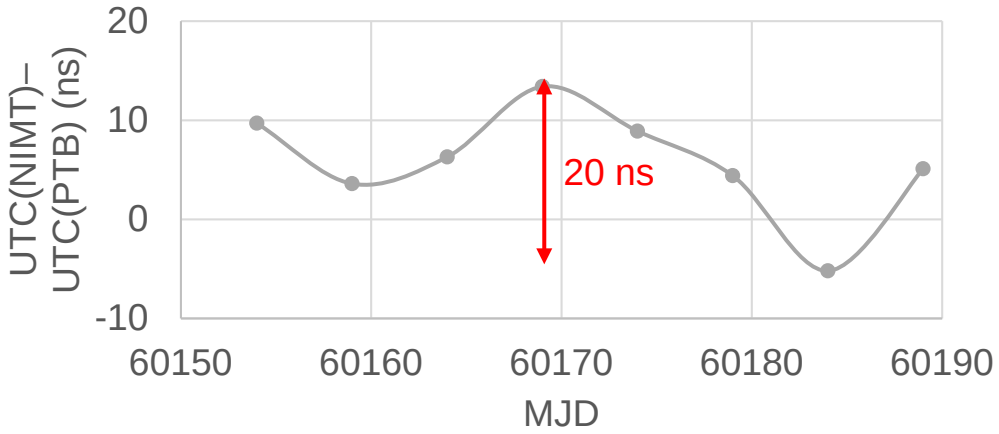
GNSS all – in – view measurements comparisons at NIMT

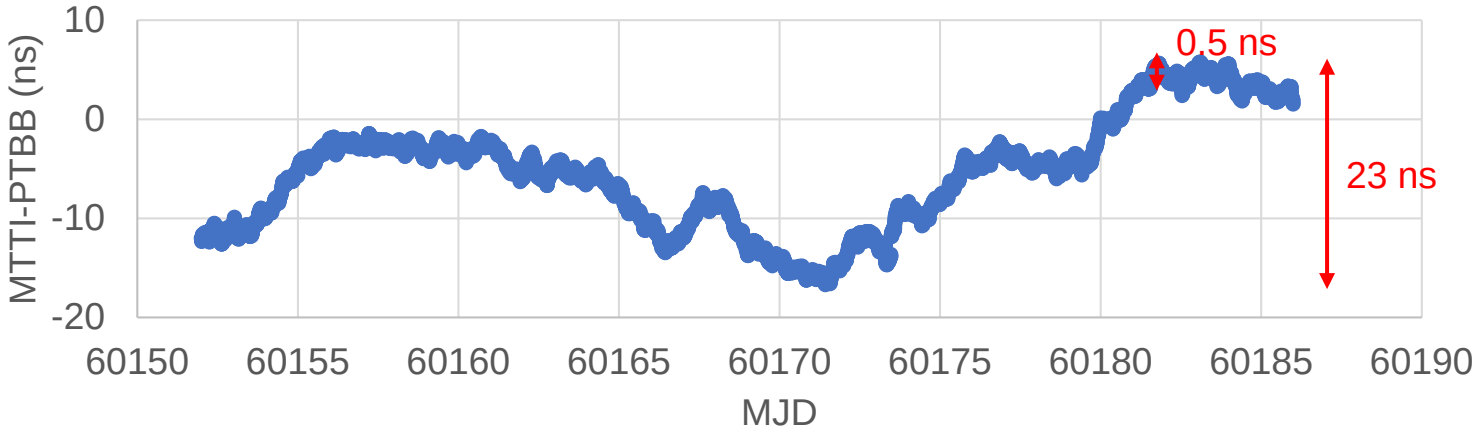


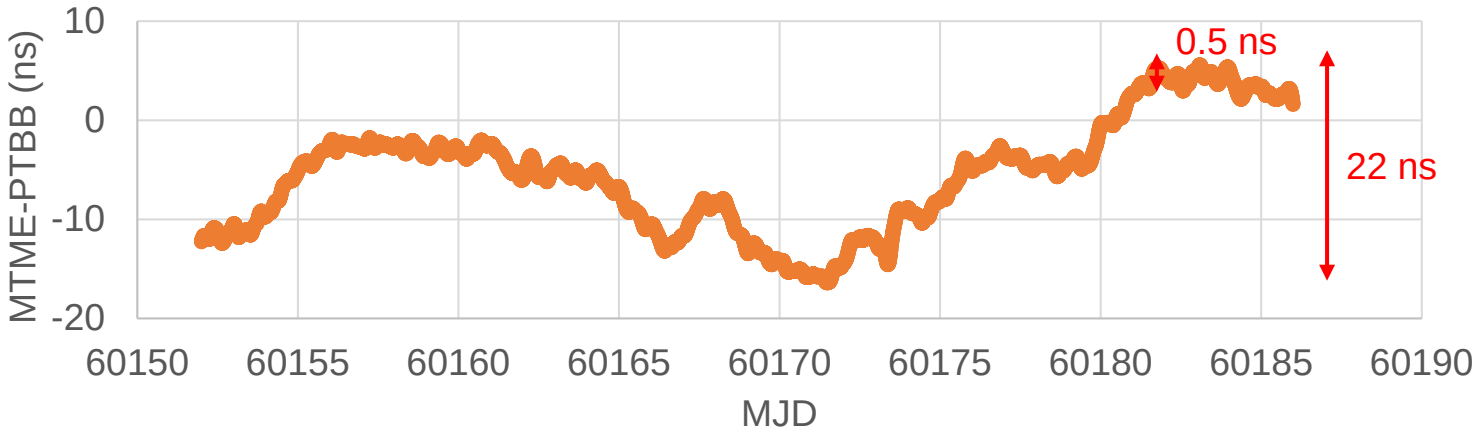
2. GNSS time transfers

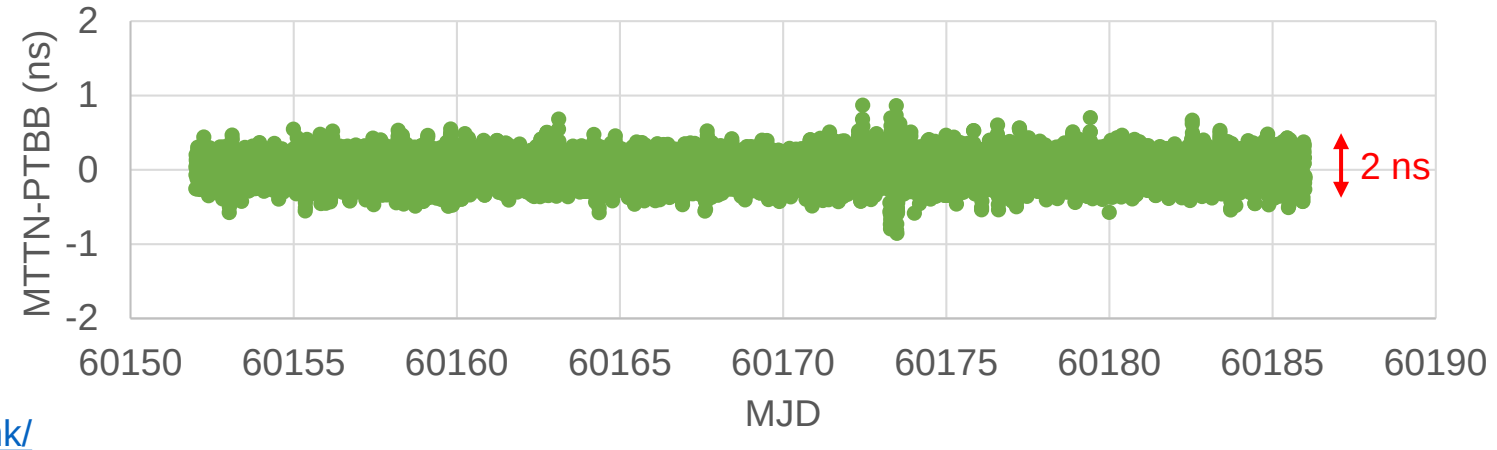
GNSS all – in – view measurements comparisons between PTB and NIMT

- Shows UTC(NIMT – UTC(PTB)
- Two **PPP** results files based on GPS observations
- August 2023 from MJD 60152 – 60185 (40 days)







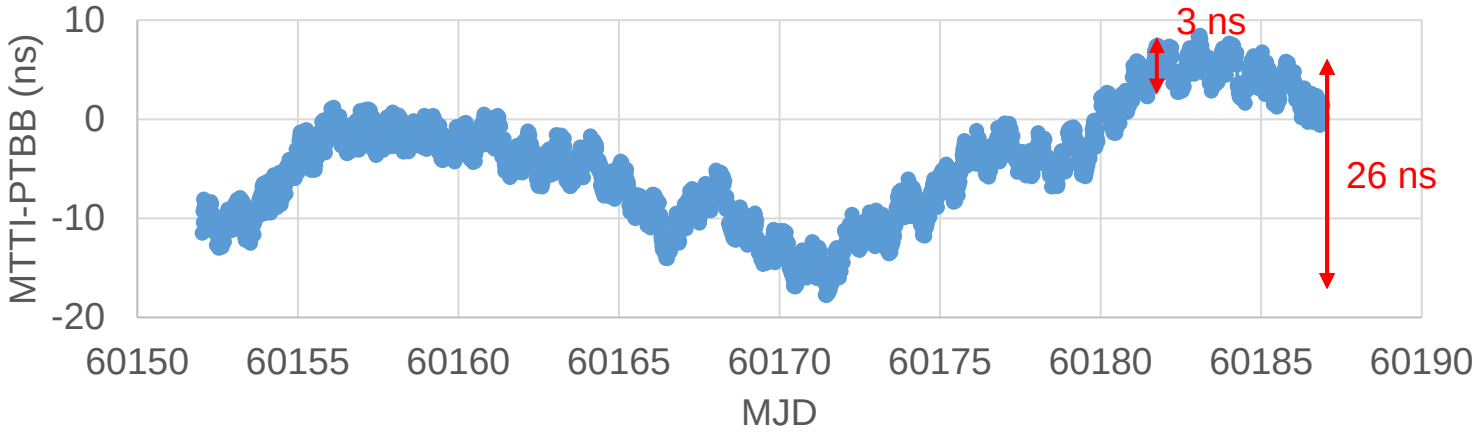


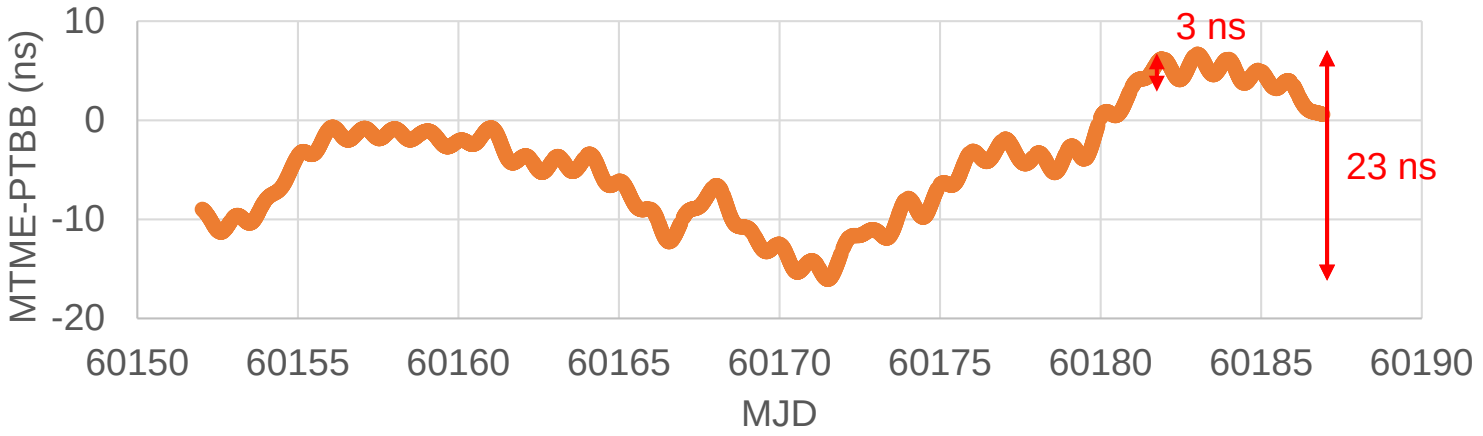
https://webtai.bipm.org/ftp/pub/tai/timelinks/lkc/2308/nimtptb/lnk/

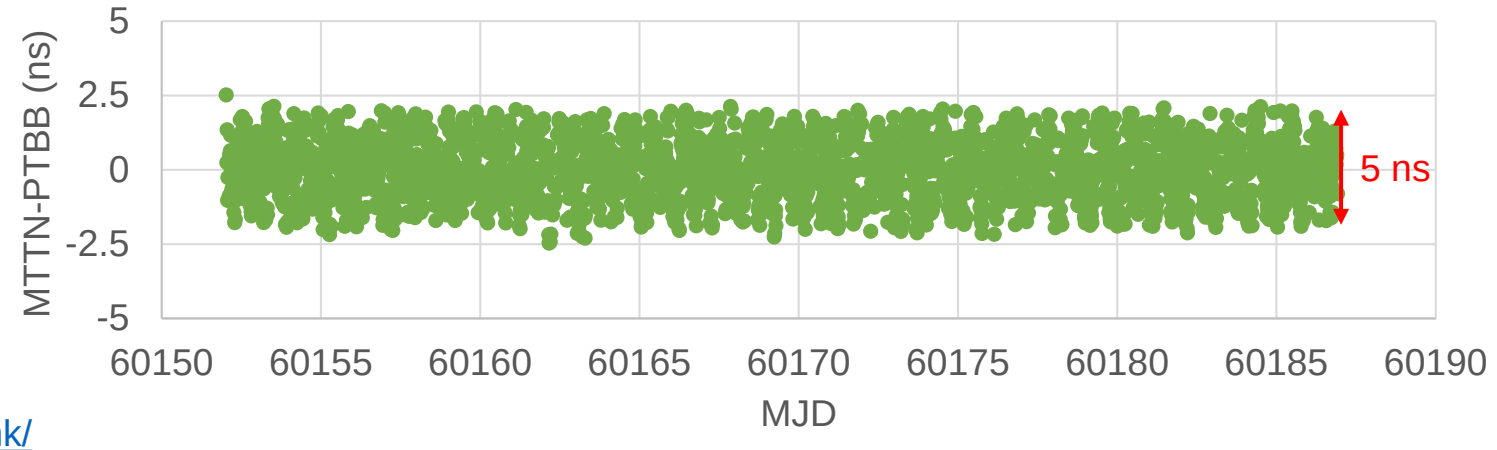
2. GNSS time transfers

GNSS all – in – view measurements comparisons between PTB and NIMT

- Shows UTC(NIMT – UTC(PTB)
- Two dual frequency, **all-in-view** GPS observations
- August 2023 from MJD 60152 – 60185 (40 days)







https://webtai.bipm.org/ftp/pub/tai/timelinks/lkc/2308/nimtptb/lnk/

3. NIMT time disseminations

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Time and frequency calibration services






Measurand	Method	Range	CMC
General frequency source	Direct measurement	1 Hz – 1 kHz	3.6×10^{-9}
		>1 kHz – 10 kHz	1.2×10^{-10}
		>10 kHz – 255 MHz	8.6×10^{-12}
Local frequency standard	Phase measurement	5 MHz and 10 MHz	1.0×10^{-13}
Time interval source	Direct measurement	100 ns – 10000 s	2 ns
Remote frequency standard	GPS common-view	5 MHz and 10 MHz	2.1×10^{-13}

Internet time information dissemination

- Internet time services for time synchronisation for computers.
  - IP dedicated for NTP servers are:
    time1.nimt.or.th
    time2.nimt.or.th
    time3.nimt.or.th
    time4.nimt.or.th
    time5.nimt.or.th
  - Precise time protocol are installed
  - White rabbit project

Digital time services	Accuracy level (s)
NTP farm	10^{-3}
PTP	10^{-6}
White rabbit	10^{-9}

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3. NIMT time disseminations

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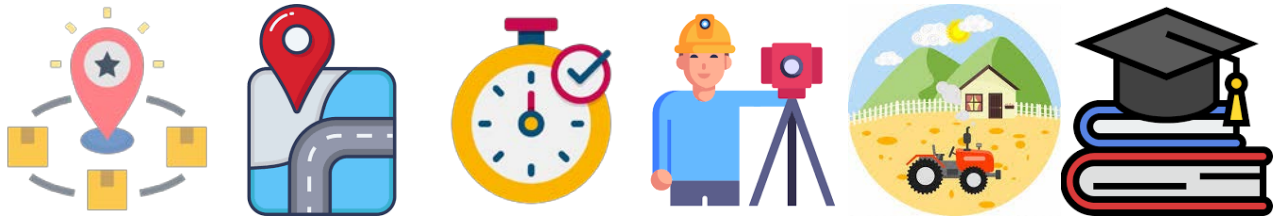
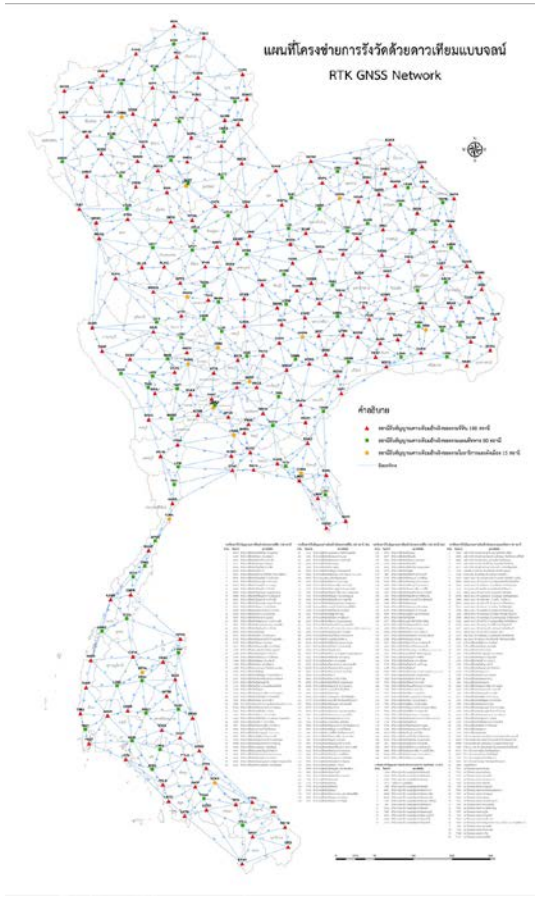
GNSS time dissemination: GNSS national permanent ground network
- Positioning and timing references
- MTTH and MTTI receivers
- RINEX and RTCM format

Services
- RTK NRTK positioning services
- GNSS observation data
- Online processing

Applications
- Reference frame determinations
- Precise time information
- Surveying and mapping
- Cadastral survey
- Precision agriculture



NCDC Portal



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4. Future plans

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GNSS receiver calibrations:

- Positioning: geodetic, survey, low-cost
- Timing: timing receiver
- Velocity: speed and INS systems
- Collaborations amongst organisation working under national positioning and timing infrastructure and national quality infrastructures

Capacity buildings: upskills and reskills

ISO documents for GNSS: receiver, NRTK and data centre

- **ISO 24245:2023** Space systems — GNSS **receiver** class codes
- **ISO 17123-8:2015 measurement systems in real-time kinematic (RTK)**
- **ISO 24246:2022** Requirements for global navigation satellite system (GNSS) positioning **augmentation centres**
- **ISO 19161-1: 2020** Geographic information — **Geodetic references — Part 1: International terrestrial reference system (ITRS)**
- **ISO/TS 21176:2020** Cooperative intelligent transport systems (C-ITS) **Position, velocity and time** functionality in the ITS station

5. Conclusions

- NIMT maintains official time scale link to UTC using GNSS measurements for time comparisons and provide time information for Thailand; also called UTC(NIMT)
- Time comparisons based on GNSS common-view, all-in-view and precise point positioning determinations for multi-GNSS constellations and multi-frequencies
- Disseminations are through internet time protocol and calibration services
- Future plans are on national quality infrastructure and capacity building to ensure trusted PNT quality scheme through collaborations

Thank you very much for your kind attentions

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