CCTF

Summary of time interoperability and way forward

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Timing interoperability

$$P^{sat\_k1} = ||x_s - x_r|| + c((t_{rec} - GNSS_1T) + errors$$

.....

$$P^{sat\_k2} = ||x_s - x_r|| + c((t_{rec} - GNSS_2T) + errors$$

.....

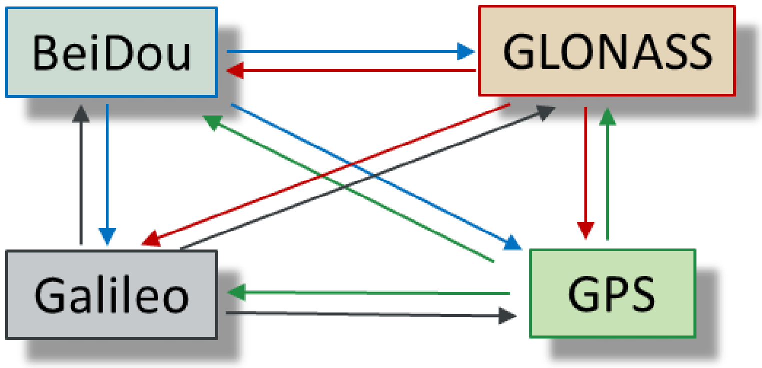
1 more unknown

→ Either determine it (if > 5 sat available)
→ Or get it from external information
(but this external GGTO does not include the receiver differential delay)

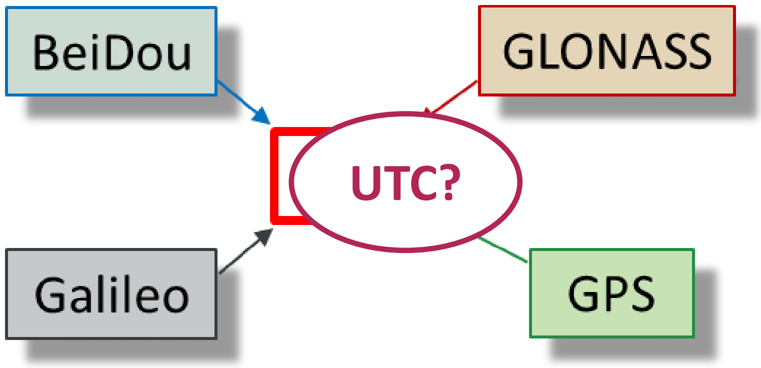
Broadcast GNSS inter-system biases

2 options :

Broadcast : [$GNSS_1T$ – $GNSS_2T$]



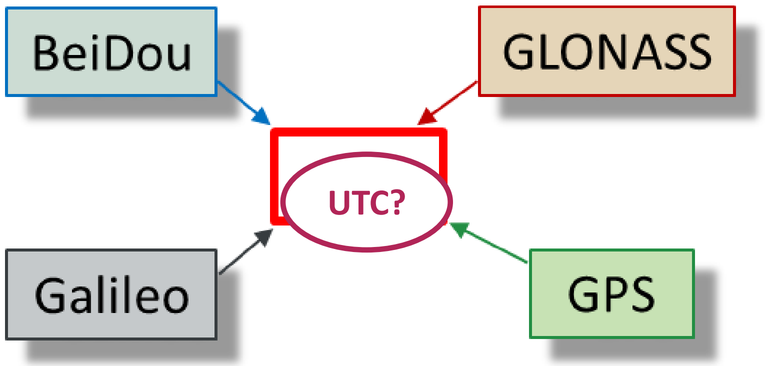
Broadcast : [GNSST – pivot]



Already broadcast:
"GNSST-$bUTC_{GNSS}$"
(modulo 1s)

GNSST-bUTC$_{GNSS}$

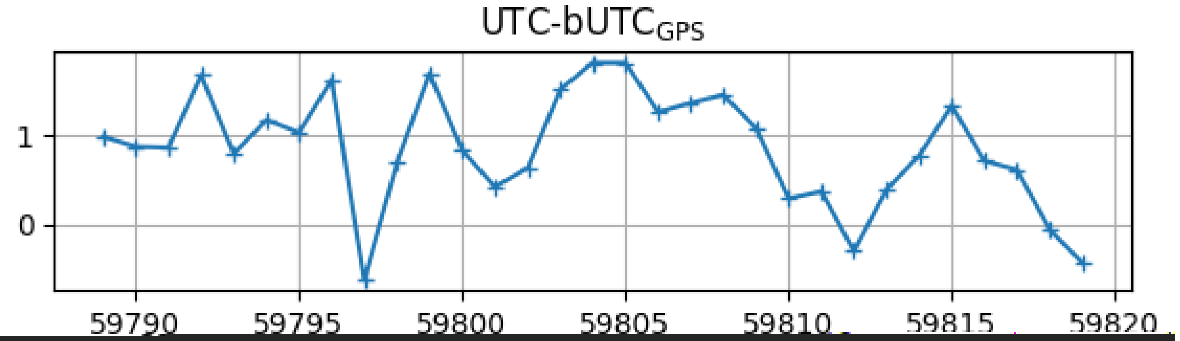
The pivot is a prediction of UTC, → not exactly the same for all GNSS

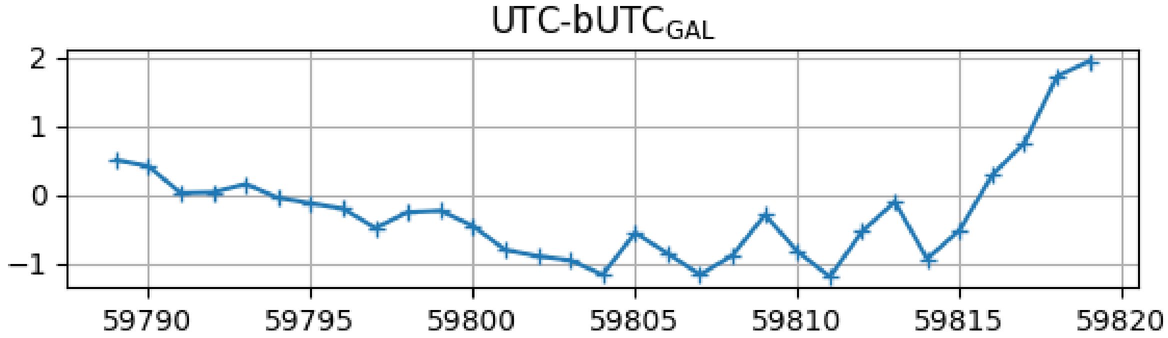


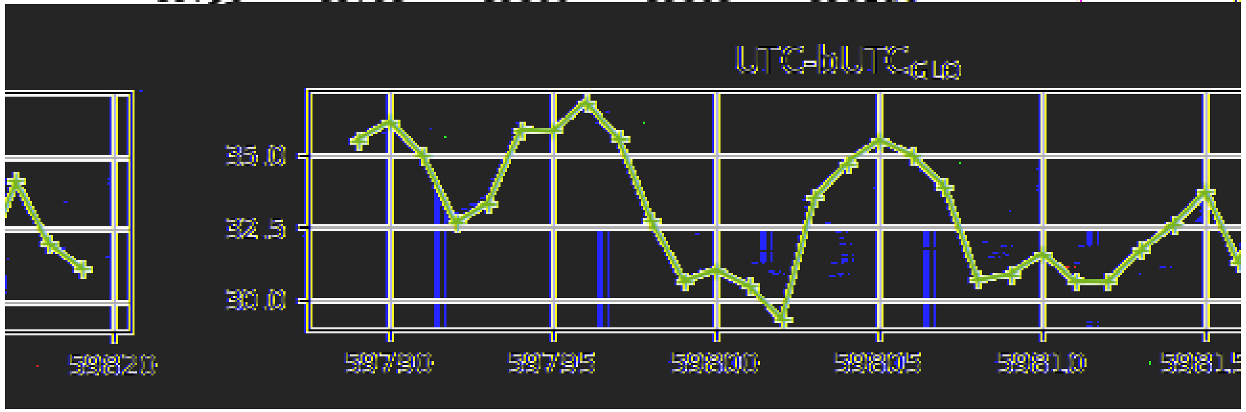
Each GNSS constellation broadcasts a different prediction, called bUTC$_{GNSS}$, based on different UTC(k)s

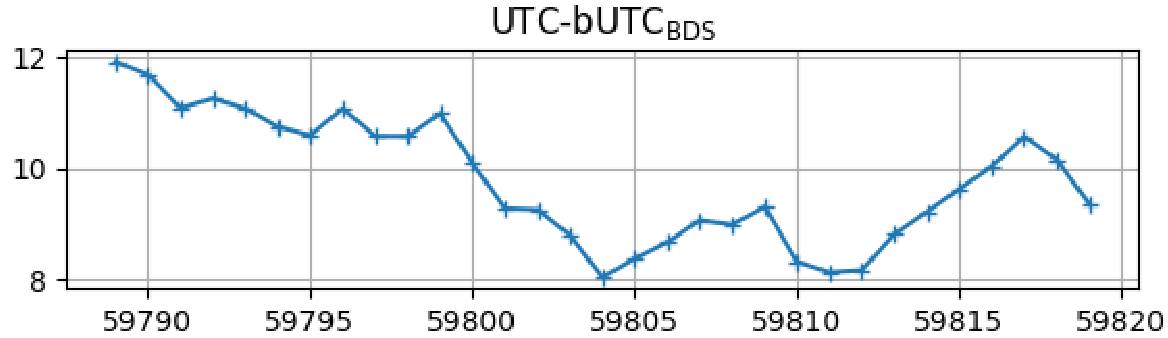
GPS → prediction of UTC(USNO)
GLONASS → prediction of UTC(SU)
BeiDou → prediction of UTC(NTSC)
Galileo → prediction of UTC from average over 5 European UTC(k)'s (IT-OP-PTB-ROA-SP)
QZSS → prediction of UTC(NICT)
NavIC → prediction of UTC(NPLI) and of UTC from CircT for NPLI

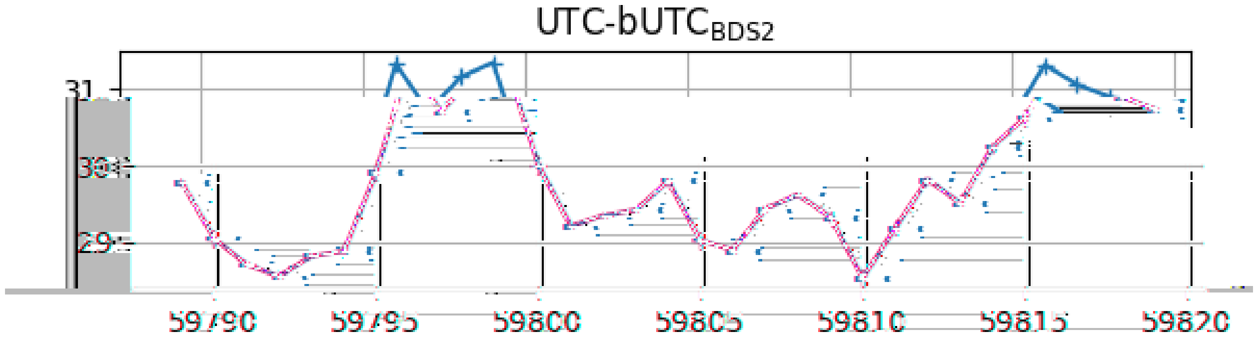
Which is the errors on the ISBs when using UTC as pivot ?









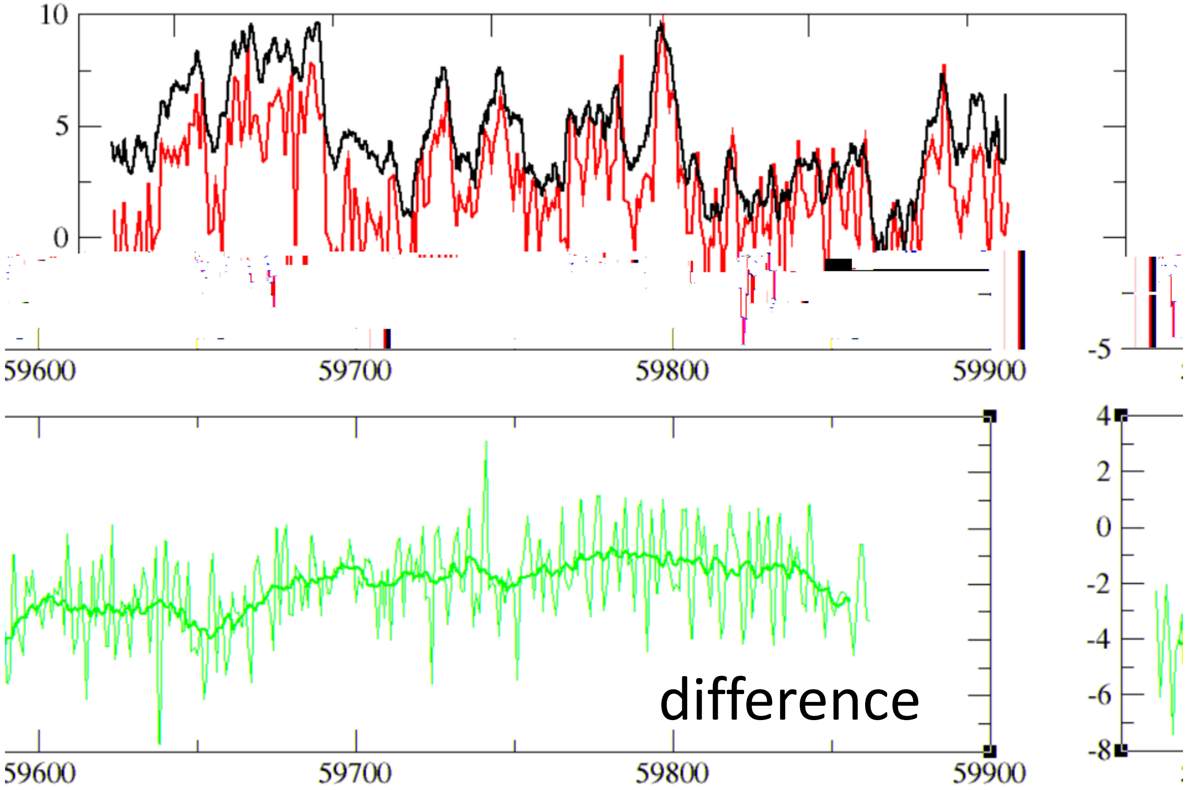


Here: August 2022
Differences up to 35 ns.
Should improve with time.

Current ISB broadcast values

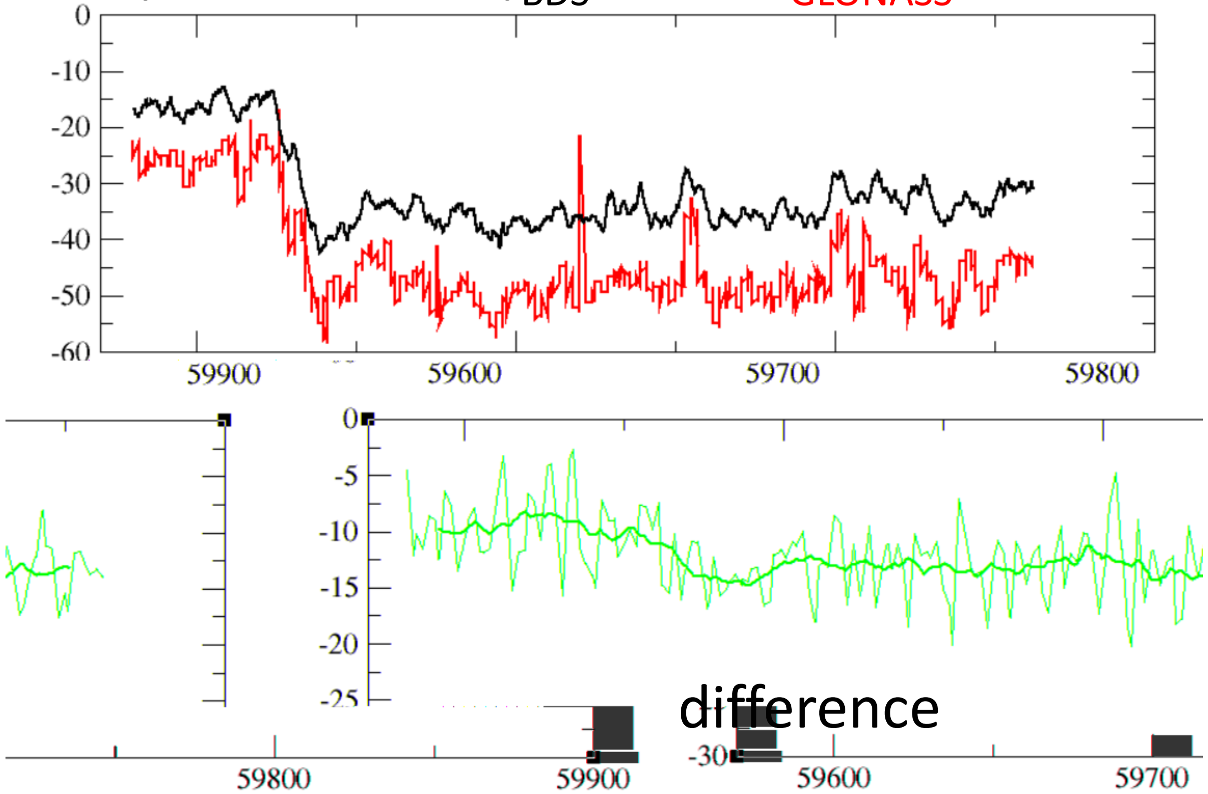
Galileo → Galileo-to-GPS (GAGP)
GLONASS → GLONASS-to-GPS (GLGP)
BeiDou → BDS-to-GPS (BDGP) / BDS-to-Galileo (BDGA) / BDS-to-GLONASS (BDGL)

$(BDGP - BDGA)_{BDS} = GAGP_{Galileo}$



Jan 1st, 2022 → now

$(BDGP - BDGL)_{BDS} = GLGP_{GLONASS}$

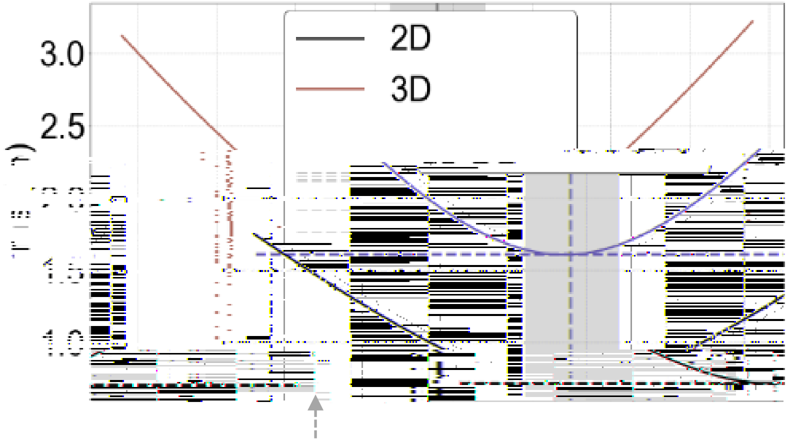


Jan 1st, 2022 → now

When is it better to fix a ISB rather than estimating it?

High precision receiver
(here the IGS station BRUX)

Full Visibility

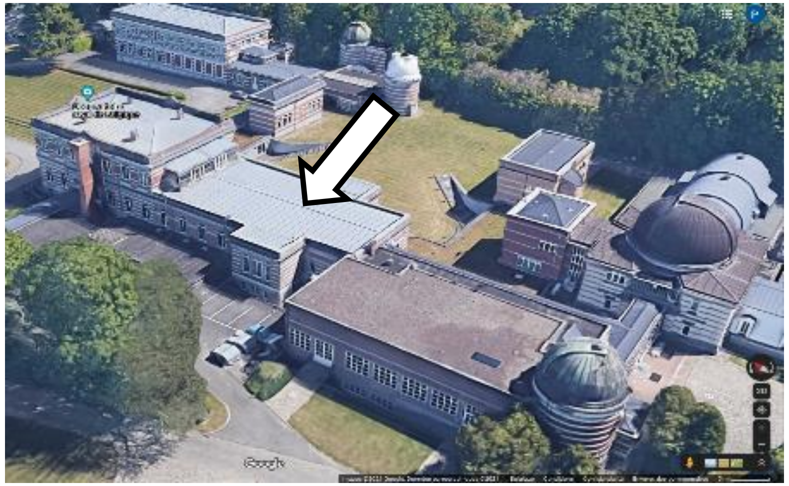


---- determine GGTO
—fix GGTO

True GGTO value (+/- 1 σ)

When is it better to fix a ISB rather than estimating it?

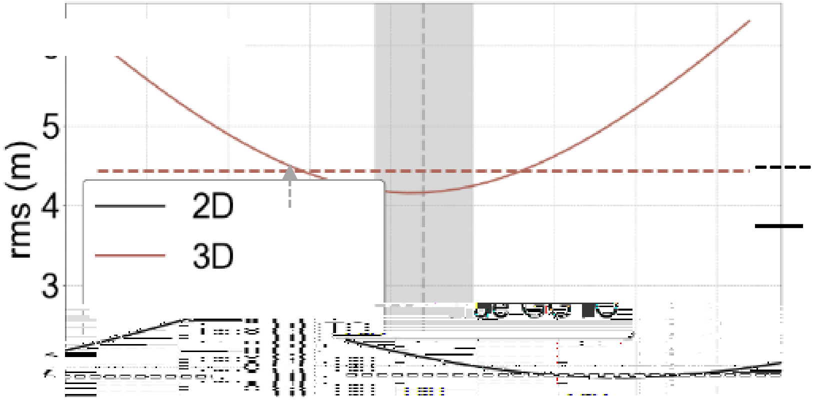
Mass-Market receiver
(here Xiaomi-MI8 smartphone)



Full visibility

If GGTO error < 7 ns:
better to fix the GGTO
Otherwise, better to determine it

Impact on 3D position errors from an error on the fixed GGTO :
4 m (error 0 ns) to 6 m (error 20 ns)



---- determine GGTO
— fix GGTO

True GGTO value (+/- 1 σ)

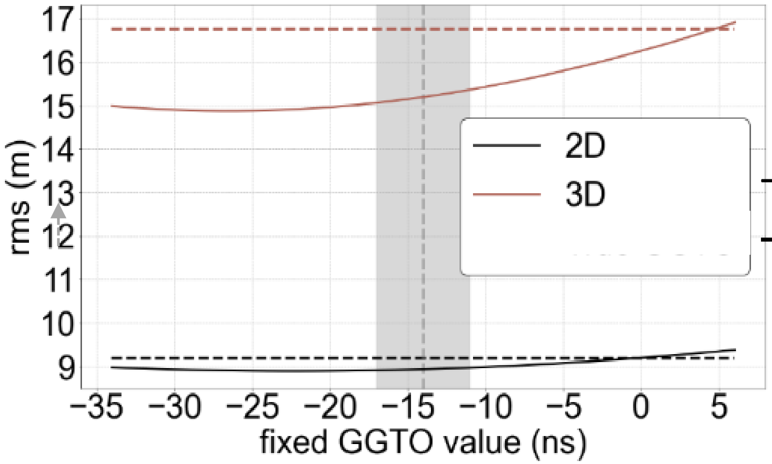
When is it better to fix a ISB rather than estimating it?

Mass-Market receiver
(here Xiaomi-MI8 smartphone)

Moderate
Urban

Always better to fix the GGTO
(for GGTO error up to 20 ns)

Impact on 3D position errors from an error on the fixed GGTO :
15 m (error 0 ns) to 16.5 m (error 20 ns)



---- determine GGTO
— fix GGTO

True GGTO value (+/- 1 σ)

Conclusion

- fixing or determining the GGTO, as well as the impact of a biased fixed GGTO value, heavily depends on the receiver noise level.

For low precision receivers:

- Fixing the GGTO provides a similar or better solution than determining the GGTO if the accuracy of the fixed GGTO is better 7 ns for a smartphone.
- a bias of 20 ns on the fixed GGTO with respect to the true value induces an increase of the position or timing errors lower than 50%

Thank You

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