



# GNSS time interoperability

## Estimation of GGTO via GNSS UTC brdc info

*The views expressed in this presentation are those of the author and do not necessarily reflect the official position of the GSA/EC*

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## Context

Each GNSS has its own time scale.

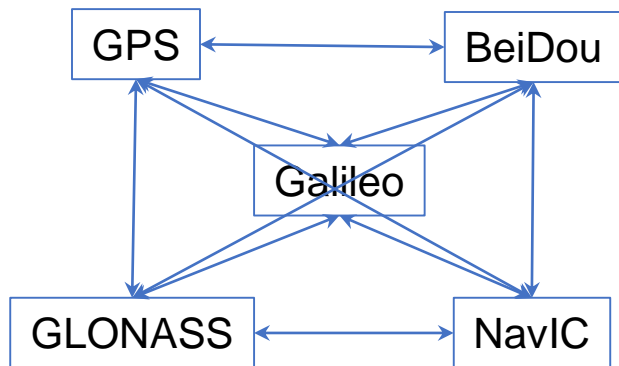
Combining measurements from different GNSS require the determination of their relative time offsets.

These relative time offsets can be :

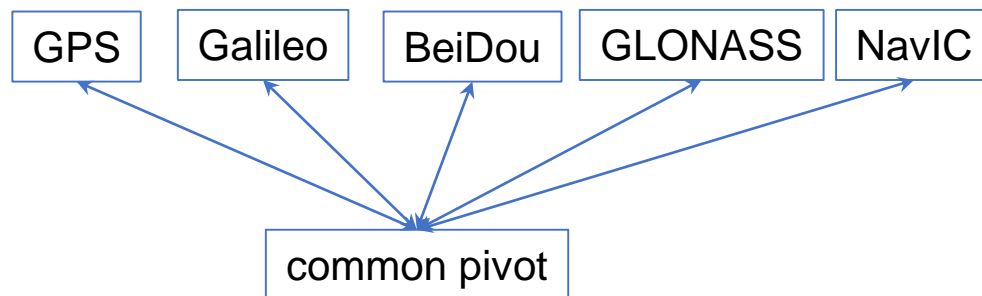
- determined at user level if sufficient measurements are available
  - >> this method shall always be preferred when possible because it is deemed to be more accurate*
- determined using a broadcast information

## Possible approaches

The inclusion of the GNSS-to-GNSS time offset (GGTO) in the broadcast information can be envisaged with 2 approaches:



Each GNSS broadcasts its time offset wrt all the other GNSS



Each GNSS broadcasts its time offset wrt a common pivot

## Common pivot

### For the common pivot, several options might be considered :

- a given GNSS time or a given UTC(k)
  - >> single point of failure : probably unacceptable
- a new time scale created externally (MGET proposal)
  - >> at least 3 drawbacks : complex, who would compute it ?, another time scale
- a new time scale created internally (xGTO proposal)
  - >> no external 3rd party, tests needed to assess perfo (see J. Hahn's presentation)
- UTCr
  - >> 10-d latency imposes extrapolation, tests needed to assess perfo
- UTC as broadcast by each GNSS
  - >> nothing additional to implement, tests needed to assess perfo

## Estimation of GGTO via GNSS UTC brdc info

Each GNSS broadcasts an estimation of GNSST – UTC(k)

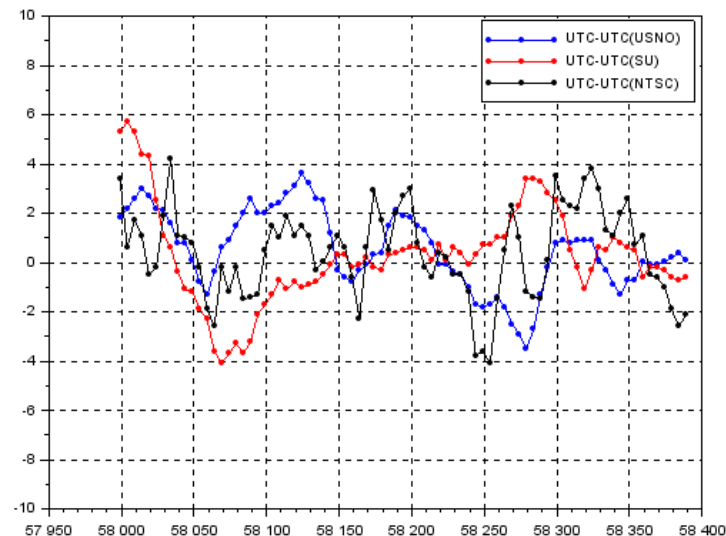
>> UTC(USNO) for GPS, UTC(SU) for GLONASS, UTC<sub>p</sub> for Galileo, UTC(NTSC) for BeiDou

Therefore this approach requires consistency of

- these estimations
- UTC(j) vs UTC(k)



UTC(k) reference time scales of GNSS are consistent with one another at  $\sim 2$  ns ( $1-\sigma$ )



## **Estimation of GGTO via GNSS UTC brdc info**

- **GPS broadcasts GPST – UTC(USNO)**
- **Galileo broadcasts GST – UTCp**

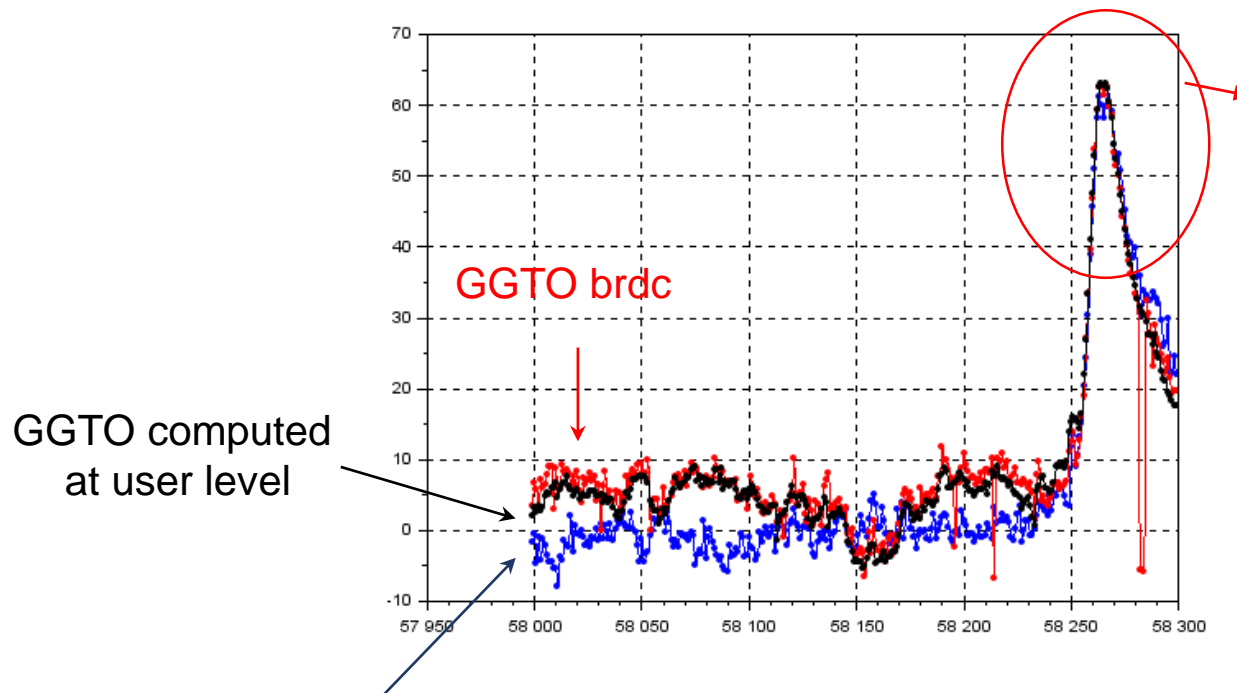
**Combining these two already existing messages, one gets GST – GPST  
but with what level of accuracy ?**

### **Test of this approach :**

- GPST – UTC(USNO) : one value per day, using the RINEX nav header of CNES station
- GST – UTCp : one value per day, using the RINEX nav header of CNES station
- computation of  $[GST - UTCp] - [GPST - UTC(USNO)]$

# Estimation of GGTO via GNSS UTC brdc info

Comparison from Sept. 2017 to July 2018



Drift of GST  
accurately reflected in  
the UTC-GST brdc info  
▶ no impact to users

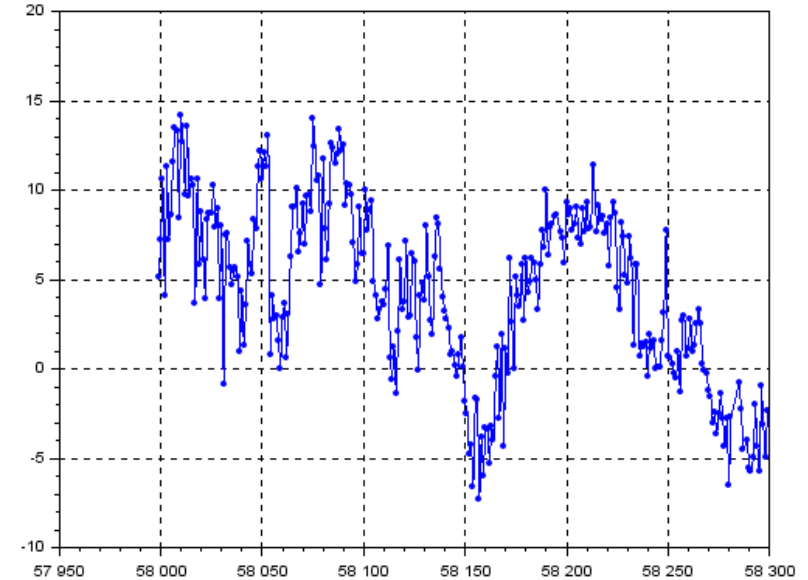
$$(GST - UTC_p) - (GPST - UTC(USNO))$$

## Estimation of GGTO via GNSS UTC brdc info

$$\text{GGTO\_brdc} - [(\text{GST} - \text{UTCp}) - (\text{GPST} - \text{UTC}(\text{USNO}))]$$

Mean = 4.4 ns  
Stdev = 4.9 ns

Good performances even over period where GST was a bit far from UTC (because the GST – UTCp correctly reflected this)



TBC whether this performance is sufficient for interoperability



## **Conclusion**

**Several possible approaches to allow GNSS users to determine the GGTOs**

**Simple approach (investigated here) makes use of already-existing broadcast information :**

- Good performance for GPS/Galileo
- To be tested with other GNSS

**Required uncertainty on GGTO is TBD**

**Thank you for your attention**

**Questions ?**



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