GNSS Time Interoperability Based on Broadcast Time Offset Parameters

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Contents

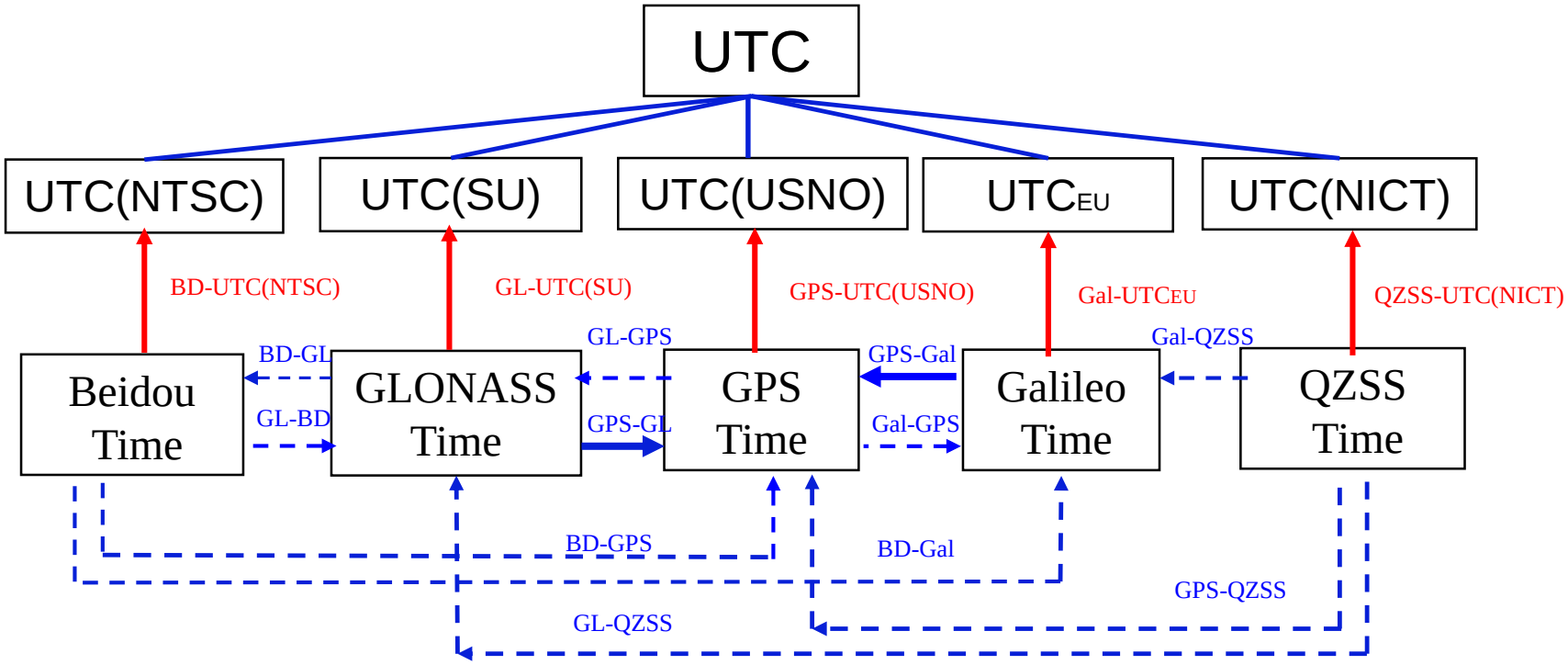
Time Referencing in GNSS

In all GNSS Satellite Time is referenced to GNSS Time and GNSS Time is referenced/synchronized to UTC(k) which is synchronized to UTC.

Users can get GNSS-GNSS Time Offset:

- autonomously – if min 4 SV of one GNSS are in view
- based on data broadcast in the navigation message:
  - GNSS-Reference Time Offset corrections
  - GNSS-GNSS Time Offset corrections (GGTO).

Time Offsets Broadcast by GNSS



Calculating GNSS-GNSS Time Offset Based on Broadcast GNSS-Reference Time Offset Parameters

GNSS-GNSS Time Offset is calculated:

$$\Delta T^{I}_{GNSSi-GNSSj} = \Delta T^{br}_{GNSSi-UTC(i)} - \Delta T^{br}_{GNSSj-UTC(j)} - \Delta T_{UTC(j)-UTC(i)}$$

The error of calculating GNSS-GNSS Time Offset:

$$\delta[\Delta T^{I}_{GNSSi-GNSSj}] = \delta[\Delta T^{br}_{GNSSi-UTC(i)}] + \delta[\Delta T^{br}_{GNSSj-UTC(j)}] + \Delta T_{UTC(j)-UTC(i)}$$

The error of broadcast corrections:

$$\delta[\Delta T^{br}_{UTC-GNSS}] \approx \delta[\Delta T^{cal}_{UTC-GNSS}] + \delta^{predict}_{UTC-GNSS}$$

The error of GNSS-GNSS Time Offset:

$$\delta[\Delta T^{I}_{GNSS-GNSS}] \approx 2\delta[\Delta T^{cal}_{UTC-GNSS}] + 2\delta^{predict}_{UTC-GNSS} + \Delta T_{UTC(j)-UTC(i)}$$

Calculating GNSS-GNSS Time Offset Based on Broadcast GNSS-GNSS Time Offset Parameters

GNSS-GNSS Time Offset is calculated:

$$\Delta T^{II}_{GNSSi-GNSSj} = \Delta T^{br}_{GNSSi-GNSSj}$$

The error of calculating GNSS-GNSS Time Offset:

$$\delta[\Delta T^{II}_{GNSSi-GNSSj}] = \delta[\Delta T^{br}_{GNSSi-GNSSj}]$$

If broadcast GGTO corrections are calculated based on simultaneous measurements by combined GNSSi/GNSSj receiver:

$$\delta[\Delta T^{br}_{GNSSi-GNSSj}] \approx \delta[\Delta T^{cal}_{GNSSi-rec}] + \delta[\Delta T^{cal}_{GNSSj-rec}] + \delta^{predict}_{GNSSi-GNSSj}$$

$$\delta[\Delta T^{II}_{GNSSi-GNSSj}] \approx 2\delta[\Delta T^{cal}_{GNSS-rec}] + \delta^{predict}_{GNSS-GNSS}$$

Calculating GNSS-GNSS Time Offset Based on Broadcast GGTO Parameters Relative to One GNSS

GNSS-GNSS Time Offset is calculated:

$$\Delta T^{III}_{GNSSi-GNSSj} = \Delta T^{br}_{GNSSi-GNSSk} - \Delta T^{br}_{GNSSj-GNSSk}$$

The error of calculating GNSS-GNSS Time Offset:

$$\delta[\Delta T^{III}_{GNSSi-GNSSj}] = \delta[\Delta T^{br}_{GNSSi-GNSSk}] + \delta[\Delta T^{br}_{GNSSj-GNSSk}]$$

If broadcast GNSS-GNSSk corrections are calculated based on simultaneous measurements by combined GNSS receiver:

$$\delta[\Delta T^{br}_{GNSS-GNSSk}] \approx \delta[\Delta T^{cal}_{GNSS-rec}] + \delta[\Delta T^{cal}_{GNSSk-rec}] + \delta^{predict}_{GNSS-GNSSk}$$

$$\delta[\Delta T^{III}_{GNSSi-GNSSj}] \approx 2 \cdot [2\delta[\Delta T^{cal}_{GNSS-rec}] + \delta^{predict}_{GNSS-GNSS}]$$

Comparison of the Methods for Calculating GNSS-GNSS Time Offsets

$$\delta[\Delta T^{I}_{GNSSi-GNSSj}] \approx 2\delta[\Delta T^{cal}_{UTC-GNSS}] + 2\delta^{predict}_{UTC-GNSS} + \Delta T_{UTC(j)-UTC(i)}$$

$$\delta[\Delta T^{II}_{GNSSi-GNSSj}] \approx 2\delta[\Delta T^{cal}_{GNSS-rec}] + \delta^{predict}_{GNSS-GNSS}$$

$$\delta[\Delta T^{III}_{GNSSi-GNSSj}] \approx 2 \cdot [2\delta[\Delta T^{cal}_{GNSS-rec}] + \delta^{predict}_{GNSS-GNSS}]$$

Comparison of the Methods for Calculating GNSS-GNSS Time Offsets

- Broadcasting GNSS-UTC(k) offset parameters is implemented in all GNSS. The accuracy of GNSS-GNSS Time Offset calculated based on broadcast GNSS-UTC(k) offset parameters can be increased by increasing the accuracy of broadcast GNSS-UTC(k) offset parameters and minimizing UTC(k)-UTC offset.
- Direct broadcasting GNSS-GNSS Time Offset parameters can provide the highest accuracy but requires implementation of additional operations.
- Calculating GNSS-GNSS Time Offset based on broadcast corrections relative to one GNSS provides generally two times lower accuracy than direct broadcasting GGTO.

Thank you for your attention!