



GNSS Time Interoperability Based on Broadcast Time Offset Parameters

T. Primakina

Russian Institute of Radionavigation and Time

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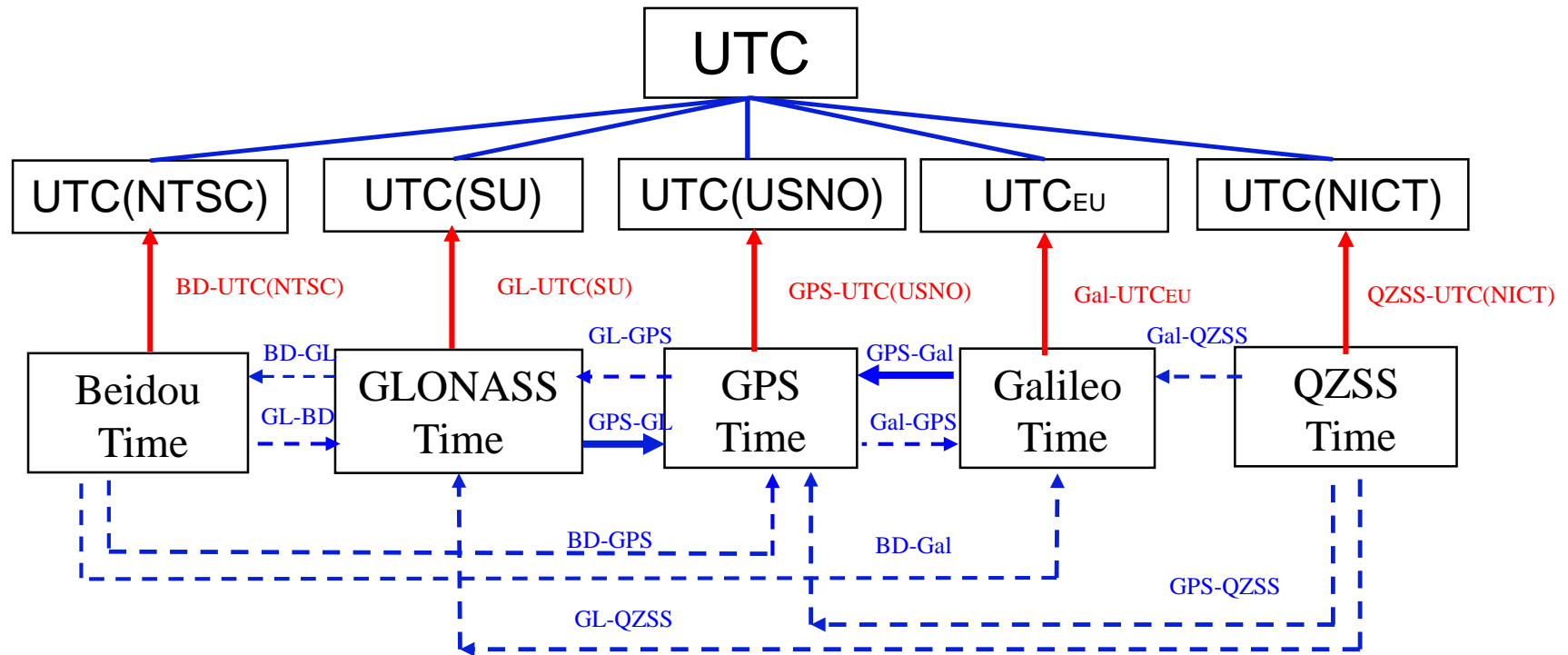
Time Referencing in GNSS

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:

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

The error of calculating GNSS-GNSS Time Offset:

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

The error of broadcast corrections:

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

The error of GNSS-GNSS Time Offset:

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

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

GNSS-GNSS Time Offset is calculated:

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

The error of calculating GNSS-GNSS Time Offset:

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

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

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

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

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

GNSS-GNSS Time Offset is calculated:

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

The error of calculating GNSS-GNSS Time Offset:

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

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

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

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

Comparison of the Methods for Calculating GNSS-GNSS Time Offsets

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

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

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

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!