Time Transfer by GNSS

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Calculation of GNSS Time/UTC by Users

Users calculate GNSS Time as:

\[ T_{GNSS} = t + \Delta T_{GNSS - SV} \]

- \( t \) - SV time
- \( \Delta T_{GNSS - SV} \) - calculated with using corrections to SV time

Broadcast corrections to SV time:

- GPS, Galileo, BeiDou and QZSS – 3 parameters
- GLONASS: FDMA – 2 parameters
  CDMA – 3 parameters
Calculation of GNSS Time/UTC by Users

Users calculate UTC as:

\[ T_{UTC(k)} = T_{GNSS} + \Delta T_{UTC(k) - GNSS} \]

- \( T_{GNSS} \) - GNSS Time
- \( \Delta T_{UTC(k) - GNSS} \) - calculated with using corrections to GNSS Time

Broadcast corrections to GNSS Time:

- GPS, Galileo, BeiDou and QZSS – 2 parameters and the whole second offset of UTC
- GLONASS: FDMA – 1 parameter
- CDMA – 2 parameters
# Parameters of Time Transfer by GNSS

<table>
<thead>
<tr>
<th></th>
<th>GPS</th>
<th>GLONASS</th>
<th>Galileo</th>
<th>BeiDou</th>
<th>QZSS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Error of SV Time - GNSS Time offset corrections</strong></td>
<td>6 m *</td>
<td>5,6 ns (RMS)</td>
<td>65 sm* (RMS)</td>
<td>2 ns</td>
<td>1,6 m (95%)</td>
</tr>
<tr>
<td><strong>Error of GNSS Time - Reference Time offset corrections</strong></td>
<td>40 ns (95%)</td>
<td>40 ns (95%)</td>
<td>28 ns (95%)</td>
<td>5 ns (95%)</td>
<td>-</td>
</tr>
</tbody>
</table>

* - URE that includes the error of SV Time-GNSS Time offset corrections
Parameters of Time Transfer by GNSS

Performance Standard Team (WG-S) – template for defining GNSS open service performance:
- Time Transfer Accuracy UUTCE
- UTC Time Dissemination Accuracy UTCOE

IGMA/IGS Joint Trial Project - a limited set of 4 monitoring parameters:
- orbit and clock error
- User range error
- UTC Offset Error
- PDOP
Methods of Time Transfer Monitoring

• **BIPM data:**
  
  \[ [\text{UTC-GNSS Time}] , [\text{UTC-UTC(k)_GNSS}] \] are transformed to
  
  \[ [\text{UTC(k)-GNSS Time}] , [\text{UTC(k)-UTC(k)_GNSS}] \]

• **Measurements at UTC(k) Generating Facilities**
  
  \[ [\text{UTC(k)-GNSS Time}] \Rightarrow [\text{UTC(k)-UTC(k)_GNSS}] \]
Results of Estimation of Time Transfer by GNSS

UTC(USNO) - UTC(USNO)_GPS

-20.0
-15.0
-10.0
-5.0
0.0
5.0
10.0
15.0
20.0

dT, ns

01/01/2019 01/03/2019 01/05/2019 01/07/2019 01/09/2019

bipm  meas.
Results of Estimation of Time Transfer by GNSS
Conclusion

• The results of estimation of Time Transfer based on BIPM data and measurements at UTC(k) Generating Facilities show some difference.

• The difference can be explained by different techniques of measurement processing and the lack of calibration of measuring facilities.
Thank you for your attention!