Towards better GNSS Observations at the new IGS Reference Station BRUX

Multi Path Mitigation and Individual Antenna Calibration

Wim Aerts, Quentin Baire, Carine Bruyninx, Juliette Legrand and Eric Pottiaux

2012-12-07
Outline

BRUX replaces BRUS

Towards better GNSS Observations

Evaluation

Conclusion
**BRUX replaces BRUS**

Towards better GNSS Observations

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Conclusion

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### From Site Log

<table>
<thead>
<tr>
<th>Site Name</th>
<th>BRUS</th>
<th>BRUX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domes Number</td>
<td>13101M004</td>
<td>13101M010</td>
</tr>
<tr>
<td>Networks</td>
<td>IGS+EPN</td>
<td>IGS+EPN</td>
</tr>
<tr>
<td>Date Installed</td>
<td>1993-10-20</td>
<td>2006-07-07</td>
</tr>
<tr>
<td>Date Removed</td>
<td>2012-02-14</td>
<td>–</td>
</tr>
<tr>
<td>Receiver</td>
<td>ASHTECH Z-XII3T</td>
<td>SEPT POLARX4TR</td>
</tr>
<tr>
<td>Antenna</td>
<td>ASH701945B_M</td>
<td>JAVRINGANT_DM</td>
</tr>
</tbody>
</table>

BRUS was removed due to construction works (asbestos removal)
BRUX replaces BRUS
Towards better GNSS Observations
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(a) EPNCB Station List

<table>
<thead>
<tr>
<th>Marker Name</th>
<th>City</th>
<th>Country</th>
<th>Lat.</th>
<th>Long.</th>
<th>H.</th>
<th>DQ (%)</th>
<th>Availability (%)</th>
<th>Latency</th>
<th>Receiver</th>
<th>Networks</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Daily BKG OLG</td>
<td>Hourly BKG OLG RT</td>
<td>Sat. System</td>
<td>IGS</td>
<td>TOS</td>
</tr>
<tr>
<td>BRLB</td>
<td>Dieltiens</td>
<td>Belgium</td>
<td>51.64</td>
<td>4.36</td>
<td>138.3</td>
<td>94</td>
<td>99</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>BRST</td>
<td>Brest</td>
<td>France</td>
<td>48.38</td>
<td>-4.50</td>
<td>65.8</td>
<td>84</td>
<td>97</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>BRUX</td>
<td>Brussels</td>
<td>Belgium</td>
<td>50.80</td>
<td>4.36</td>
<td>138.3</td>
<td>94</td>
<td>99</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>Former</td>
</tr>
<tr>
<td>BSCN</td>
<td>Besançon</td>
<td>France</td>
<td>47.26</td>
<td>5.99</td>
<td>359.5</td>
<td>79</td>
<td>96</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

(b) BRUX
(c) On Google Maps
(d) BRUS

Wim Aerts
Towards better Observations at BRUX
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  Individual Antenna Calibration

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Constraints

- Cost of RF absorbing material
- Limit shield weight and dimensions
- Minimum antenna to absorber spacing
- Limit horizontal and vertical displacement of antenna
Shielding the Telescope Dome Doors

antenna

shield with absorber

sliding doors

38 cm

28 cm

80 cm

80 cm

180 cm

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Antenna Support

JA VRINGANT_DM

PVC-HI
ANW-77
AlMgSi 1

sliding doors
Minimum Antenna to Absorber Spacing

\[ S_{11} \text{ [dB]} \]

\[ f \text{ [GHz]} \]

-10
-20
-30
-40

1
1.25
1.50
1.75
2.00

0 cm
10 cm
\( \infty \)
Some Other Examples

ONSA setup (left) from T. Ning (et al) “The impact of microwave absorber and radome geometries on GNSS measurements of station coordinates and atmospheric water vapour” (2011)

Bird Nest (right) from A. Kerkhoff (et al) “Modifications to GPS Reference Station Antennas to Reduce Multipath” (2010)
Effect of Absorbers in Line Of Sight (LOS)

Material adds delay (2 mm for ASH701945C_M in ANW-79 on GPS L1)
Type versus Individual Calibration

Type from igs08.atx versus Individual from UniBonn:

<table>
<thead>
<tr>
<th>frequency</th>
<th>ΔPCO North</th>
<th>ΔPCO East</th>
<th>ΔPCO Up</th>
<th>% within ±1 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS L1</td>
<td>−0.62 mm</td>
<td>0.70 mm</td>
<td>10.09 mm</td>
<td>85%</td>
</tr>
<tr>
<td>GPS L2</td>
<td>−1.22 mm</td>
<td>0.44 mm</td>
<td>5.33 mm</td>
<td>82%</td>
</tr>
<tr>
<td>GPS L3</td>
<td>0.31 mm</td>
<td>1.10 mm</td>
<td>17.45 mm</td>
<td>78%</td>
</tr>
</tbody>
</table>
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Multi Path Indicators

BRUS – BRUX Local Tie

Conclusion
Multi Path Sky Plots (Preliminary Results)

MP1 and MP2 rms values from BNC:

BRUX 2011–043 (without ANW-77)

BRUX 2012–030 (with ANW-77)
$C/N_0$ Curves (Preliminary Results)

$C/N_0$ [dB]

- $G07$ (10 s sampling interval)
- 2012 DOY 030 (with ANW-77)
- 2011 DOY 043 (without ANW-77)
Day Boundary Clock Jumps (Preliminary Results)

Consecutive days calculated with Atomium (PPP)

<table>
<thead>
<tr>
<th>year</th>
<th># days</th>
<th>minimum (ps)</th>
<th>maximum (ps)</th>
<th>stdev (ps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>10</td>
<td>-205</td>
<td>171</td>
<td>127</td>
</tr>
<tr>
<td>2012</td>
<td>8</td>
<td>-100</td>
<td>152</td>
<td>86</td>
</tr>
</tbody>
</table>

2010 setup: MJD 55234–55244 (DOY 025–035)
ASHTECH Z-XII3T connected to CH1-75A maser
ASH701945C_M without ANW-77

2012 setup: MJD 55965–55973 (DOY 039–047)
SEPT POLARX4TR connected to CH1-75A maser
JAVRINGANT_DM with ANW-77
BRUS–BRUX Local Tie

<table>
<thead>
<tr>
<th>method</th>
<th>∆X</th>
<th>∆Y</th>
<th>∆Z</th>
<th>∆R</th>
</tr>
</thead>
<tbody>
<tr>
<td>terrestrial</td>
<td>-12.1690</td>
<td>-47.3262</td>
<td>23.7428</td>
<td>54.3284</td>
</tr>
<tr>
<td>GPS L3 type/indiv (diff to terr)</td>
<td>-12.1640</td>
<td>-47.3295</td>
<td>23.7428</td>
<td>54.3302</td>
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<tr>
<td></td>
<td>-0.0050</td>
<td>0.0033</td>
<td>0.0000</td>
<td>-0.0018</td>
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<tr>
<td>GPS L3 type/type (diff to terr)</td>
<td>-12.1640</td>
<td>-47.3283</td>
<td>23.7430</td>
<td>54.3292</td>
</tr>
<tr>
<td></td>
<td>-0.0050</td>
<td>0.0021</td>
<td>-0.0002</td>
<td>-0.0008</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>method</th>
<th>∆N</th>
<th>∆E</th>
<th>∆U</th>
<th>∆R</th>
</tr>
</thead>
<tbody>
<tr>
<td>terrestrial</td>
<td>27.1967</td>
<td>-46.2645</td>
<td>8.4563</td>
<td>54.3284</td>
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<td>GPS L3 type/indiv (diff to terr)</td>
<td>27.1931</td>
<td>-46.2682</td>
<td>8.4593</td>
<td>54.3302</td>
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<tr>
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<td>0.0037</td>
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<tr>
<td>GPS L3 type/type (diff to terr)</td>
<td>27.1931</td>
<td>-46.2670</td>
<td>8.4595</td>
<td>54.3292</td>
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<td>0.0036</td>
<td>0.0025</td>
<td>-0.0032</td>
<td>-0.0008</td>
</tr>
</tbody>
</table>

NOTE: individual calibration of BRUS antenna is planned.
BRUS was shut down, BRUX replaced BRUS in EPN and IGS

To improve quality of observations at BRUX
  - the dome was shielded
to avoid reflections reaching the antenna
  - the antenna was individually calibrated
    at the anechoic chamber of uniBonn

The terrestrial BRUS-BRUX survey showed good agreement with the distance as obtained from GPS L3 calculations
Acknowledgments

- Solar Terrestrial Network of Excellence (STCE)
- Andria Bilich, Jim Ray, Guy Vandenbosch, Philipp Zeimetz, ...