Differential BDS in China and the Research of DBDS standard in the Framework of RTCM

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Contents

- About Differential BDS (DBDS)
- Performance of DBDS
- Research of DBDS standard
About DBDS
About Differential BDS

- Differential GNSS techniques to improve the accuracy of real time positioning
- Differential GNSS classified by the data sources
  - Code differential (CDBDS), 0.3m~2m
  - Phase differential (RTK), 0.02m~0.10m
  - State Space Representation (SSR), 0.1m~1.0m
- CORS, GBAS, RBN-DGNSS, etc. are used
- RTCM SC104 protocols are to support the DGNSS applications
Performance of DBDS
DBDS Test network

- 30+ reference stations
- Hubei Province BDS Network RTK System
- BDS/GPS/GLONASS
HuBei BDS Network RTK system

30 reference stations
Reference stations

- BDS/GPS Receiver, UPS, Route, Switch etc.

**tower:**
- high 3.5m
Data center

- Located at Hubei Surveying & Mapping Bureau

Building of Hubei SMB

Control Center
Software

- **Functions**
  - RS management
  - Data process
  - User management

- **Systems**
  - BDS B1, B2, B3
  - GPS L1, L2
  - GLONASS L1, L2
# User receiver—BDS/GPS OEM

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Freq</strong></td>
<td>Beidou B1/B2 + GPS L1/L2</td>
</tr>
<tr>
<td><strong>Positioning Mode</strong></td>
<td>Support point positioning using Beidou only, GPS only, and Beidou/GPS</td>
</tr>
<tr>
<td><strong>BDS</strong></td>
<td>Support Beidou B1/B2, Support Beidou point positioning, differential Beidou, and high precision relative positioning</td>
</tr>
<tr>
<td><strong>Differential Corrections</strong></td>
<td>CMR,CMR+,RTCM2.x,RTCM3.x</td>
</tr>
<tr>
<td><strong>RTK Positioning</strong></td>
<td>Support instant RTK and long range RTK</td>
</tr>
<tr>
<td><strong>RTK accuracy</strong></td>
<td>Horizontal: 1cm+1ppm Vertical: 2cm+1ppm</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>1.6W</td>
</tr>
<tr>
<td><strong>WAAS</strong></td>
<td>Support WAAS and PPP</td>
</tr>
</tbody>
</table>
User receiver

- RTK Rover
- GIS data collector
- .......
Testing items

- Reference Station Coordinates
- Static post-processing
- Network RTK
- Code Differential
- Precision Point Positioning
Experiments and Results

- Reference Station Coordinates—CGCS2000 (BDS data only)

  RMS H: 0.006m, RMS V: 0.015m

<table>
<thead>
<tr>
<th>ECEF RMS</th>
<th>Baseline Repeative</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMS</td>
<td>Fixed + Scale</td>
</tr>
<tr>
<td>X</td>
<td>0.007m 6.7mm + 2.8 × 10^{-8}</td>
</tr>
<tr>
<td>Y</td>
<td>0.010m 10.0 mm + 1.6 × 10^{-8}</td>
</tr>
<tr>
<td>Z</td>
<td>0.006m 5.8mm + 3.0 × 10^{-8}</td>
</tr>
</tbody>
</table>

2013-11-21
Experiments and Results - Static post-processing

7 Days Positioning Result Vs. GPS (Dynamic, epoch by epoch)

<table>
<thead>
<tr>
<th></th>
<th>dE (mm)</th>
<th>dN (mm)</th>
<th>dU (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>9</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>Beidou</td>
<td>5</td>
<td>13</td>
<td>32</td>
</tr>
</tbody>
</table>

- GPS: 9717
- Beidou: 6512

20% precision improved using BDS+GPS than single GPS (Dynamic)

DOY170 (Dynamic) Vs. GPS
Experiments and Results—NETRTK

- Network RTK Positioning
  - BDS B1/B2 + GPS L1/L2

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fixed (%)</th>
<th>Initial Time (s)</th>
<th>STD/m (Average)</th>
<th>RMS/m (Average)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>H</td>
<td>V</td>
</tr>
<tr>
<td>GPS+BDS3</td>
<td>100%</td>
<td>5.76</td>
<td>0.004</td>
<td>0.018</td>
</tr>
<tr>
<td>GPS+BDS2</td>
<td>80%</td>
<td>27.46</td>
<td>0.003</td>
<td>0.015</td>
</tr>
<tr>
<td>BDS3</td>
<td>83%</td>
<td>16.40</td>
<td>0.007</td>
<td>0.020</td>
</tr>
<tr>
<td>BDS2</td>
<td>40%</td>
<td>50.78</td>
<td>0.003</td>
<td>0.015</td>
</tr>
<tr>
<td>GPS</td>
<td>44%</td>
<td>40.28</td>
<td>0.006</td>
<td>0.021</td>
</tr>
</tbody>
</table>
Experiments and Results—CDBDS

- Dynamic testing
- 1Hz position output
- RMS: 0.67m, 1.5m (95%)

<table>
<thead>
<tr>
<th>Mode</th>
<th>BDS L1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Points number</td>
<td>1344</td>
</tr>
<tr>
<td>1Sigma</td>
<td>0.67m</td>
</tr>
<tr>
<td>95%</td>
<td>1.44m</td>
</tr>
</tbody>
</table>
Experiments and Results—PPP

- PPP B1/B2 and B1/B2/B3

![Graph showing Tri_fre and Dual_fre with RMS values]
Research of DBDS standard in the framework of RTCM SC104
RTCM SC104 DGNSS Service

- Radio Technical Commission for Maritime services Special Committee No.104 (RTCM SC104) provides to DGNSS standard
- Using for manufactory, R&D, Service provider etc.
- Versions:
  - RTCM SC10402.3 for DGNSS applications
  - RTCM SC10403.2 for high precision applications
The thoughts of adding BDS Messages

☐ For RTCM SC10402.X
  - Add: B1 Code differential messages
  - Modified: Some messages

☐ For RTCM SC10403.X
  - Add: BDS Network RTK Corrections
  - Add: BDS Satellite Ephemeris
  - Add: BDS SSR
  - Comments: MSM messages etc.
The progress in 2013

- Attend the RTCM SC104 conference in Nashville, Sept 2013
- Wuhan Navigation & LBS Inc. suggested to form BDS Working Group to provide BDS support to RTCM committee.
- Dr. Shaowei Han was elected as RTCM SC104 the BDS WG chair. Dr. HuiLiu is the secretary.
- There were 15+ organizations apply to attend the BDS WG
  - Trimble, Novatel, Geo++, Navcomm, etc.
Upcoming Meetings:
30-31 January 2014
Bahia Hotel
San Diego, CA, USA
Transport and Lodging Information

21-22 May 2014
European Space Operations Centre
Darmstadt, Germany

8-9 September 2014 (to be confirmed)
Tampa, FL, USA

Reference Materials
- RTCM Bylaws
- RTCM Standards Development Policies
- Galileo ICD
- BeiDou ICD
- RTCM 3.2 Message Sample/Template

Active Working Groups | Chair
---|---
RTK Network MSG | Frank Takac
Internet Protocol | Georg Weber
GALILEO | Hans-Jürgen Euler
GLONASS | Alexei Zinoviev
DGNSS Beacon Services | Al Cleveland
Private Services | Ivo Milev
State Space | Gerhard Wübben
Version 3 | Paul Alves
Coordinate Transformation | Martin Schmitz
RINEX | Ken MacLeod
BeiDou | ShaoWei Han
Conclusions

- BDS is in operation. The performance of DBDS in China is satisfied to the most user’s requirements.
- It is necessary to define the DBDS unified interface between service provider and end users.
- The full BDS messages in RTCM SC-104 standards are needed as quick as possible so that worldwide GNSS manufacturers can participate those campaigns.
- BDS WG will push it to happen faster.
Thanks you very much for the attention!

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