

Report
PPP-RTK & Open Standards Symposium 2012
Frankfurt am Main, Germany
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In this note, I report on the 'PPP-RTK & Open Standards Symposium' that was organized by the German Federal Agency for Cartography and Geodesy (BKG) in Frankfurt am Main on 12-13 March 2012. I participated in the symposium, representing the CRCSI as its Positioning Program's Science Director. The day after the symposium, some s/w tools were demonstrated at the BKG remises. I did not attend that demonstration.

The symposium was well organized and from the number of participants one can infer that the topic of PPP-RTK has the interest of a great many groups. There were 180 participants from more than 30 countries!

After Welcome, Opening and Introduction, the first day (the complete two-day program is attached to this report; for the presentations, see <http://igs.bkg.bund.de/ntrip/symp#PresentationFiles>) was organized in presentations on the following topics: a) RTCM; b) Global Ionosphere; c) Regional augmentation; d) Ambiguity Resolution.

- a) RTCM: An overview was given of the plans to modernize the RTCM, in particular with the aim of being able to support PPP-RTK. Although many details still need to be worked out and not all (commercial) service providers are yet willing to comment on these plans, I find this RTCM development an important one. One can expect that the new RTCM will become the open standard for PPP-RTK. Aspects that the new RTCM will support, next to its support of standard PPP, are multi-GNSS, phase bias corrections, and ionospheric information (perhaps even slant ionosphere).
- b) Global Ionosphere: With the further densification of global networks, improved ionospheric modeling becomes possible. Overviews were given of the initiatives of some institutes to provide global ionospheric 'maps'. This is important for PPP in general, single-frequency users in particular, but it is not yet at the level that would be needed for PPP-RTK.
- c) Regional Augmentation: Here, as well as in other sessions, examples were presented of how PPP and PPP-RTK could be aided with the help of regional networks. Some of the suggested and presented approaches of augmentation, I find rather cumbersome, because if PPP-RTK is properly implemented and executed, then also the regional augmentation should blend in and follow the PPP-RTK data streams. Regional augmentation is particularly important for the provision of atmospheric parameters.

- d) Phase Biases and Ambiguity Resolution: This session was not so much on ambiguity resolution, but more on phase biases. Unfortunately no real discussion took place on pros and cons of the different approaches and no consensus was reached. From the presentation and discussion it became clear that one can roughly speak of a Czech approach (Mervart), a French approach (Laurichesse), a Canadian approach (Collins), and a Chinese approach (Ge). (I did not present the Curtin method.) It is also clear that there is disagreement between the authors of these approaches. It seems that RTCM, for now, favors the French approach.

Day two of the symposium gave an overview of current and planned developments from service providers in the fields of PPP and PPP-RTK. The second day was organized in the topics: a) Existing Services; b) Emerging Services; c) Product Dissemination; d) Tools and Applications.

- a) Existing Services: Here the following companies gave their presentation: Trimble, Fugro, John Deere and Veripos. Fugro and Veripos mainly operate offshore, while Trimble and John Deere mainly operate onshore. All four were tight-lipped on the methodology used, although all four claim to use, depending on the circumstances, ambiguity resolution of some sort (but how and when, remained unclear). All four claim to achieve between 5cm (Trimble) and 10cm (Veripos) real-time, global positioning. These values have to be interpreted with care, because it was not made clear what confidence percentages were used (e.g., 95% or something else) and whether this is 3D or only horizontal. These claimed position accuracies are achieved *after* convergence, which ranged between 25 minutes and 45 minutes. Trimble so far seems to be the only company that has a regional augmentation network (80 stations in the USA Midwest with station distance of about 120 km) that enables them to further improve their solution for that region, in particular bringing the convergence times down to a few minutes.
- b) Emerging Services: Next to the IGS overview of its real-time products, and the Wuhan University regional augmentation system, two presentations were given on QZSS. The first topic was on QZSS as augmentation system. The second was on QZSS as GEONET-based PPP-correction delivery system for users in Japan. It was stated by the Japanese presenters that it is not clear yet whether or not Japan will charge fees to the users.
- c) Product Dissemination: Next to the presentation on NTRIP, highlighting how integrity is realized through redundancy, and the presentation on the 'lightsquared' controversy, an interesting presentation was given on using Satellite TV Links as platform delivery system for PPP-RTK corrections. A proof of concept of the system is currently under development and it works very much

like a 'pay-tv system'. The concept allows great flexibility, since by working with encrypted keys it can provide many different sorts of data streams.

- d) Tools and Applications: In this last session, two presentations were given on applications (precision farming and tsunami-buoy monitoring) and two on PPP-RTK tools. In the presentation on RTKLIB, it was announced that this open source s/w is expected to have a first version of PPP-RTK functionality in the second half of this year. From the presentation on the topic of the Network-RTK Service Provider it became clear that also Network-RTK providers are realizing the importance of PPP-RTK, and are therefore working on contributing to PPP-RTK, mostly as an augmentation system.

Conclusions and Advice:

1. This was a very useful and well-organized symposium. It has confirmed the importance of PPP-RTK and it has demonstrated a rapidly increasing interest in the topic.
 2. The decision by the CRCSI to choose for a PPP-RTK development in Australia is well-founded and consistent with international trends.
 3. Information about the atmosphere, in particular the ionosphere, is currently a bottleneck for PPP-RTK. Regional augmentation, enabling the provision of such information, is therefore important. Unfortunately, panel experts at the symposium were not able (or not willing) to provide values for the required inter-station distances, other than stating that it will be between something like 100 to 200 km.
 4. The realization of 'Open Standards' is very important in light of the many ongoing and planned developments.
 5. The multi-GNSS component was not very prominently represented. That is, no expectations (except w.r.t. QZSS) were exchanged as to what the integration of multi-GNSS will bring extra to PPP-RTK.
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1. Given the importance of 'Open Standards', it is advised that the CRCSI keeps a close eye on the RTCM Open Standards development and on the progress of the associated working group.
 2. Given the importance of having real-time and accurate ionospheric information available, it is suggested to consider the built-up and realization of an Australian Ionospheric Service aimed at PPP-RTK. The existing international initiatives are Northern Hemisphere dominant.
 3. Given the facts that the 'phase biases' are the truly essential components of PPP-RTK and that various different and seemingly unlinked 'phase bias' definitions are used, it is important that the CRCSI obtains a clear and in-depth understanding of the various 'phase bias' definitions and their properties.

4. Since the platform delivery mechanism for PPP-RTK corrections is an important component of any operational PPP-RTK system (for Australia in particular), the CRCSI is advised to also consider to survey the potential of the 'Satellite TV Link' concept as discussed at the symposium. The concept allows great flexibility, since by working with encrypted keys it can provide many different sorts of data streams. This would therefore open up the possibilities to provide services to a great variety of users, having different accuracy and integrity requirements. Moreover these need not be PNT users only.

PJG Teunissen, Perth, 16-3-2012



**PPP-RTK & Open Standards
Symposium, March 12-13, 2012
Workshop, March 14, 2012**

Literaturhaus Frankfurt
Schöne Aussicht 2
D-60311 Frankfurt am Main
Germany

Program, Day 1

Monday, 12th March 2012

08:30 **Registration**

09:00 **Opening and Introduction**

Global Geodetic Observing System and the Contribution of GNSS

*Hansjörg Kutterer, President of the Federal Agency for Cartography and Geodesy (BKG),
Chair of Global Geodetic Observing System (GGOS), Frankfurt, Germany*

From GPS to GNSS – Challenges and Prospects

*Urs Hugentobler, Chair International GNSS Service (IGS) Governing Board,
Institute for Astronomical and Physical Geodesy, Technical University Munich, Germany*

Kinematic GNSS towards Real-time

*Volker Schwieger, International Federation of Surveyors (FIG), Commission 5,
Institute of Engineering Geodesy, University of Stuttgart, Germany*

Enabling GNSS Standards that Support Emerging Positioning and Related Technologies

*Rudy Kalafus, Radio Technical Commission for Maritime Services (RTCM), Special Committee on
Differential Global Navigation Satellite Systems (SC-104), Arlington, VA, U.S.A.*

10:00 **Essentials**

Chair: *Georg Weber, Federal Agency for Cartography and Geodesy (BKG), Frankfurt, Germany*

RTCM State Space Representation (SSR), Overall Concept Towards PPP-RTK

*Gerhard Wübbena, RTCM SC104, Chair of State Space Representation Working Group, Geo++ GmbH, Garbsen,
Germany*

RTCM State Space Representation Messages, Status and Plans

Martin Schmitz, Geo++ GmbH, Garbsen, Germany

RTCA SBAS DO-229 Today and in the Future with GNSS Evolutions

*Michel Tossaint, European Space Agency, European Space Research and Technology Centre, Noordwijk, The
Netherlands*

11:00 Coffee Break



11:30 **Global Ionosphere**

Chair: *Tim Springer, European Space Agency, Space Operations Centre (ESA/ESOC), Darmstadt, Germany*

Generating Global and Regional Ionospheric Delay Model for Real-time Precise Point Positioning Service
Hongping Zhang, Research Center for Geoscience, Potsdam, Germany

Fast Precise Point Positioning Based on Real-time Ionospheric Modelling

Manuel Hernandez-Pajares, Res. Group of Astronomy and Geomatics, Universitat Politecnica de Catalunya, Barcelona, Spain

Global TEC Service for Ionospheric Delay Correction and Different Approaches for Higher Order Effects Mitigation

Mainul Hoque, German Aerospace Center (DLR), Institute of Communications and Navigation, Neustrelitz, Germany

12:30 Lunch

13:30 **Regional and Local Augmentations**

Chair: *Neil D. Weston, Spatial Reference Systems Division, National Geodetic Survey, National Oceanic and Atmospheric Administration, Silver Spring MD, U.S.A.*

Augmenting Global Real-time PPP Service with Regional Reference Network for Instantaneous cm-Level Positioning

Maorong Ge, Research Center for Geoscience, Potsdam, Germany

Strategy for an Internet Based Best Effort Regional PPP Product Delivery Free from Outages and Outliers – The EUREF Example

Wolfgang Söhne, Federal Agency for Cartography and Geodesy, Frankfurt, Germany

GNSS Precise Point Positioning in Regional Reference Frames Using Real-time Broadcast Corrections
Lennard Huisman, Kadaster, Apeldoorn, The Netherlands

15:00 Coffee Break

15:30 **Phase Biases and Ambiguity Resolution**

Chair: *Paul Collins, Geodetic Survey Division, Natural Resources Canada, Ottawa*

Phase Biases Estimation for Undifferenced Ambiguity Resolution

Denis Laurichesse, Centre National D'Etudes Spatiales, Toulouse, France

Processing GNSS Data in Real-time: Algorithms, Issues, and Challenges

Leos Mervart, GPS Solutions Inc., Boulder CO, U.S.A. and Geodetic Institute, Czech Technical University, Prague, Czech Republic

Results from Bernese IGS Workshop “GNSS Biases” on 18-19 Jan 2012

Stefan Schaer, Astronomical Institute, University of Bern, Switzerland

17:00 End of Day 1

19:00 Evening Event



Program, Day 2

Tuesday, 13th March 2012

09:00 Existing Services

Chair: *Matthias Becker, Institute of Physical Geodesy, Technical University Darmstadt, Germany*

Worldwide Centimeter Accurate GNSS Positioning Using Trimble RTX Technology
Herbert Landau, Trimble Terrasat GmbH, Höhenkirchen, Germany

Fugro's Precise (Point) Positioning Services
Kees de Jong, Fugro Intersite B.V., Leidschendam, The Netherlands

Title: TBD

Chaochao Wang, NavCom Technology, Torrance, Canada (enquired)

Providing Global GNSS Augmentation Data – A Commercial Service Provider's Perspective
Pieter Toor, VERIPOS, Norwich, Great Britain

10:30 Coffee Break

11:00 Emerging Services

Chair: *Robert Weber, Institute of Geodesy and Geophysics, University of Technology Vienna, Austria*

The IGS Real Time Infrastructure: From Pilot Project to Operational Service
Loukis Agrotis, European Space Agency, European Space Operations Center (ESA/ESOC), Darmstadt, Germany

Galileo Commercial Service – Status and Opportunities
Marco Dettratti, European GNSS Agency, Brussels, Belgium

Centimeter-Class Positioning Augmentation Utilizing Quasi-Zenith Satellite System
Yuki Sato, Mitsubishi Electric Corporation, Amagasaki Hyōgo, Japan

JAXA's PPP Experiment via QZSS
Motoyuki Miyoshi, Japan Aerospace Exploration Agency (JAXA), Tsukuba, Japan

12:30 Lunch

13:30 Prototype of Multi-Constellation Augmentation Service System in China
Yidong Lou, GNSS Research Center, Wuhan University, Wuhan, China

13:55 Product Dissemination

Chair: *Jürgen Rüffer, ALLSAT & AXIO-NET, Hannover, Germany*

Mass-Usage of Ntrip for GNSS Product Dissemination, Experiences and Perspectives
Dirk Stöcker, Alberding GmbH, Schönefeld, Germany

Broadcasting Via TV Satellite Links:

Subscription Based and Secure GNSS Data Transmission & Loss-less RTCM Data Compression
Rafal Mielniczuk, University of Applied Science Konstanz (HTWG), Germany

Broadband Spectrum Controversy, in GNSS/PPP Context, Pros & Cons

Gavin Schrock, Washington State Reference Network and Professional Surveyor Magazine, Seattle, U.S.A.

15:00 Coffee Break



15:30 **Tools and Applications**

Chair: *Peter Teunissen, Cooperative Research Centre for Spatial Information, Perth, Australia*

PPP Ambiguity Resolution Implementation in RTKLIB v 2.4.2

Tomoji Takasu, Tokyo University of Marine Science and Technology, Japan

Precision Farming, Sensor Applications for Guidance Systems

Marcus Reutemann, John Deere European Technology Innovation Center, Kaiserslautern, Germany

PPP-RTK from the Network RTK Service Providers' Point of View

Tamás Horváth, Institute of Geodesy Cartography and Remote Sensing, Budapest, Hungary

Development of Japanese Disaster Mitigation System Using Real-time PPP with Ambiguity Resolution for
Tsunami Buoys & Ground Networks

Masayuki Kanzaki, Hitachi Zosen Corporation, Tokyo, Japan

16:45 **Wrap-up**

Georg Weber, Federal Agency for Cartography and Geodesy, Frankfurt, Germany

17:00 End of Symposium

Workshop & Tutorial, Day 3

Wednesday, 14th March 2012

09:00 **Future SSR Messages and Related Open Source Software Tools**

Future RTCM Message Contents and Design for PPP-RTK/SSR

Gerhard Wübbena, RTCM SC104, Chair of State Space Representation Working Group, Geo++ GmbH, Garbsen, Germany

Introduction to Real Time Kinematic Library (RTKLIB) Usage

Tomoji Takasu, Tokyo University of Marine Science and Technology, Japan

Introduction to BKG Ntrip Client (BNC) Usage

Leos Mervart, GPS Solutions Inc., Boulder CO, U.S.A. and Geodetic Institute, Czech Technical University, Prague, Czech Republic

Ntrip Modernization and Professional Ntrip Caster

Dirk Stöcker, Alberding GmbH, Schönefeld, Germany

13:00 Lunch

14:00 Further discussions with BKG colleagues if wanted