ION GNSS 2011

A Novel Device for Autonomous Real-Time Precise Positioning with Global Coverage

SEPTEMBER 21st , 2011 - ION GNSS 2011, PORTLAND, OREGON, USA

SESSION E1: PRECISE POINT POSITIONING AND RTK

D. Calle
A. Mozo
P. Navarro
R. Píriz
D. Rodríguez
G. Tobías

INNOVATING SOLUTIONS

OUTLINE

- Introduction to Precise Point Positioning (PPP)
- Products for PPP
- Precise products dissemination
- PPP Messages over Iridium
- User Terminal Overview
- Phase Ambiguity Resolution
- Conclusions

PPP: PRECISE POINT POSITIONING

- Absolute positioning technique based on undifferenced, dual-frequency observations coming from a single GNSS receiver, together with detailed physical models and corrections, and precise GNSS orbit and clock products calculated beforehand.

- Additional corrections used to mitigate systematic effects which lead to centimeter variations in the undifferenced code and phase observations; phase wind-up corrections, satellite antenna offsets, station displacements due to tides (earth and oceanic), etc.

- Observations coming from satellites are processed together in a process that solves for the different unknowns; the receiver coordinates, phase ambiguity terms, receiver clock offset and zenith tropospheric delay.

PRODUCTS FOR PPP (1)

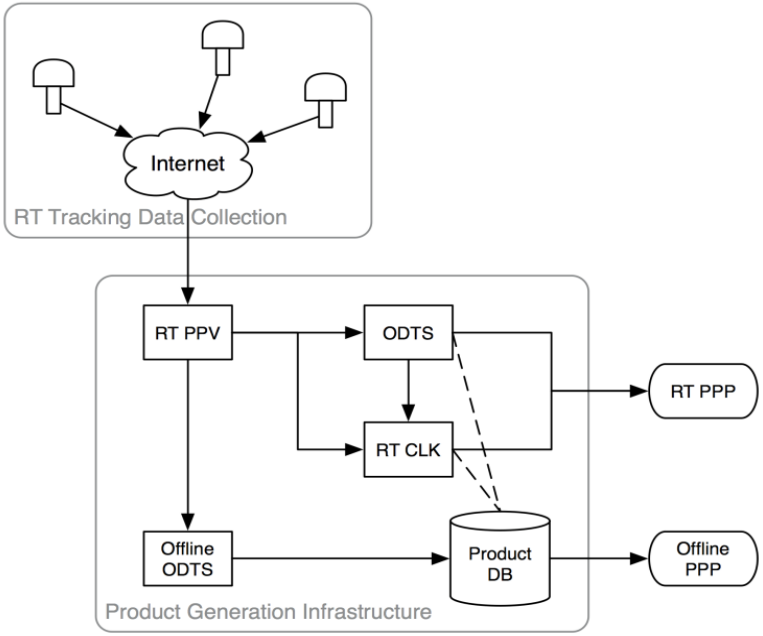
- GMV: Infrastructure for generation of precise GPS and GLONASS orbits and clocks for real time and post-processing applications

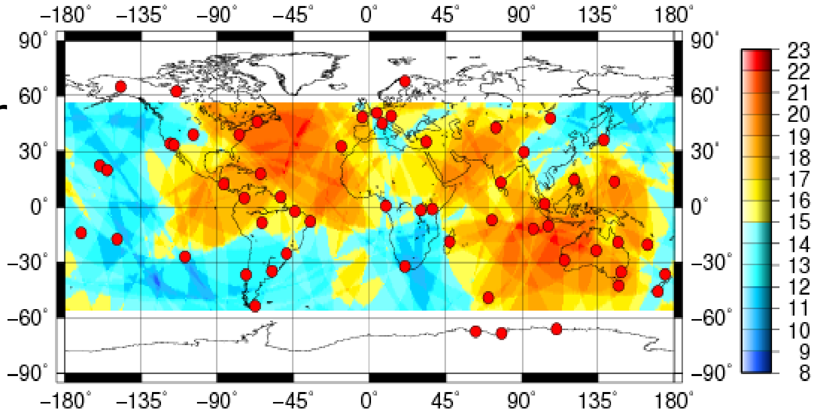
- Data retrieval, from a worldwide station network via NTRIP

- PPV makes iono-free and geometry-free measurements available to the different algorithms

- ODTS processes 2-days every 15 minutes. Provides satellite orbits and other estimated parameters

- RT_CLK estimates satellite clocks in real time with inputs from PPV and the outputs from the last ODTS execution



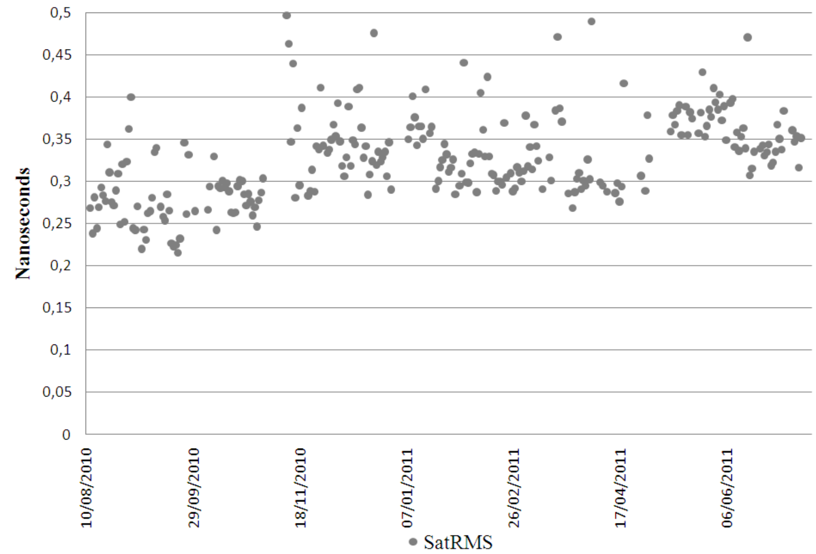


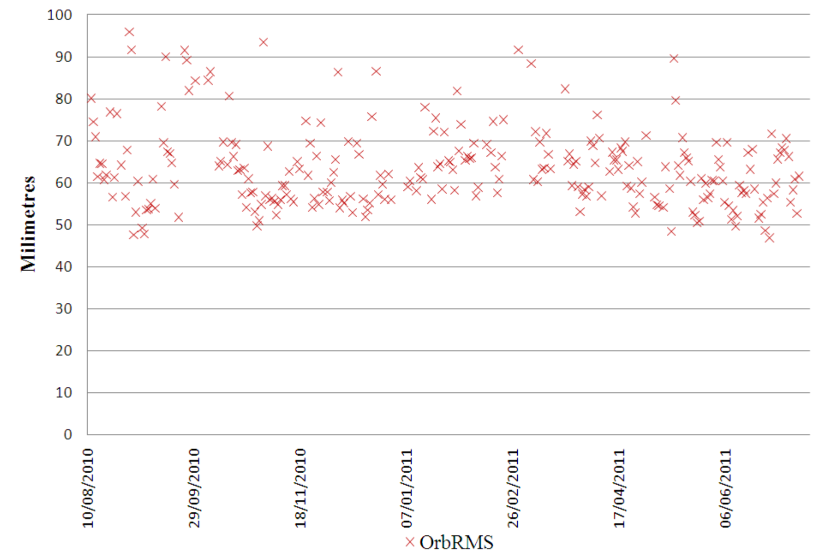
PRODUCTS FOR PPP (2)

- Real-time orbits and clocks available as data stream to real-time processing algorithms, and stored in standard formats (SP3, clock RINEX) to be used as reference products for *magicGNSS* PPP service

- Real time products contribute to the IGS Real Time Pilot Project since 2010

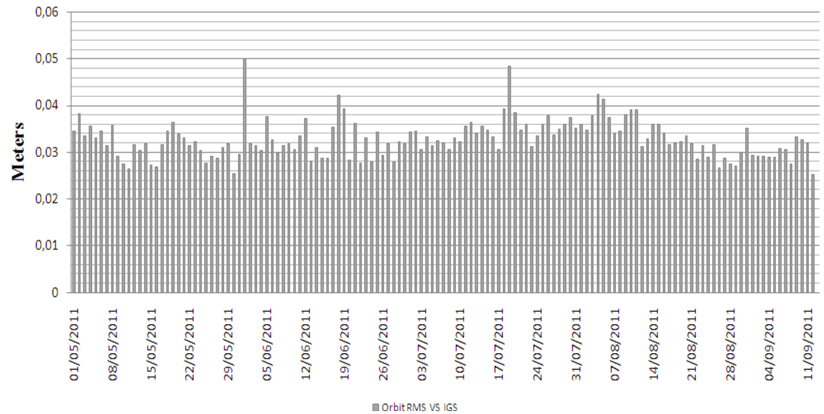
- The clock RMS stays around 0.3 ns and the 15 minute prediction orbit error stays around 6 cm with respect to IGS.

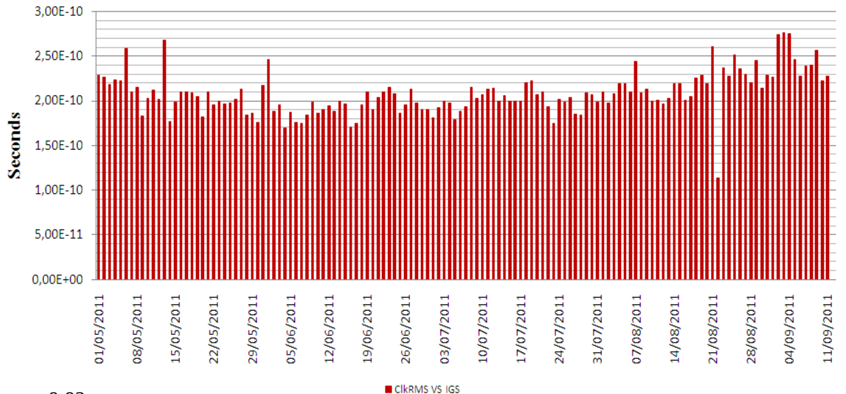


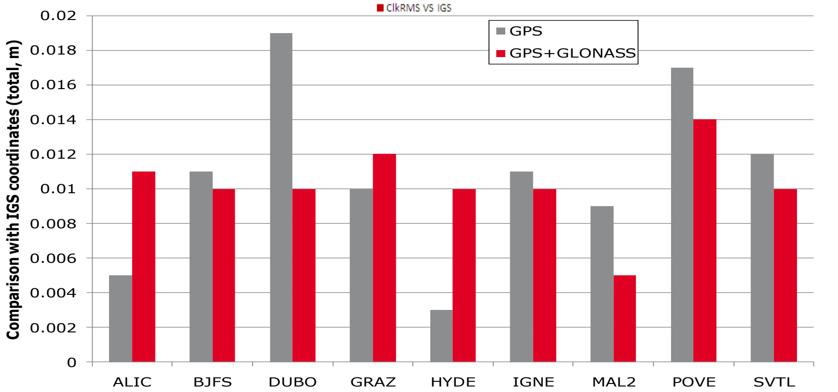


PRODUCTS FOR PPP (3)

- Offline ODTS process running in off-line post-processing mode with a latency of 2 days
- Specific setup and larger amount of data allows the generation of more precise products than the real time ones
- IGS comparison: typical orbit performances around than 3cm, and clock accuracy is around 0.2ns
- Product quality (GPS and GPS + Glonass) monitored via PPP of 9 IGS stations. 1 centimeter nominal error







PRECISE PRODUCTS DISSEMINATION (1)

- Once reference products are available in RT, next problem to tackle it their transmission to the user, both format and channel.

- <u>Sending full information implies large bandwidth</u> -> Navigation messages under RTCM standard are already available to any professional receiver, sending corrections to this ephemeris is a more practical approach.

- Draft RTCM specification already supports RT corrections for PPP in the so-called "state-space representation" or SSR. Several messages available.

- Additional messages needed for broadcasting satellite fractional biases used in PPP for carrier-phase ambiguity resolution -> Current RTCM-SSR draft specification does not specifically accommodate for such biases:

  – Re-utilize some of the existing messages, like code bias messages

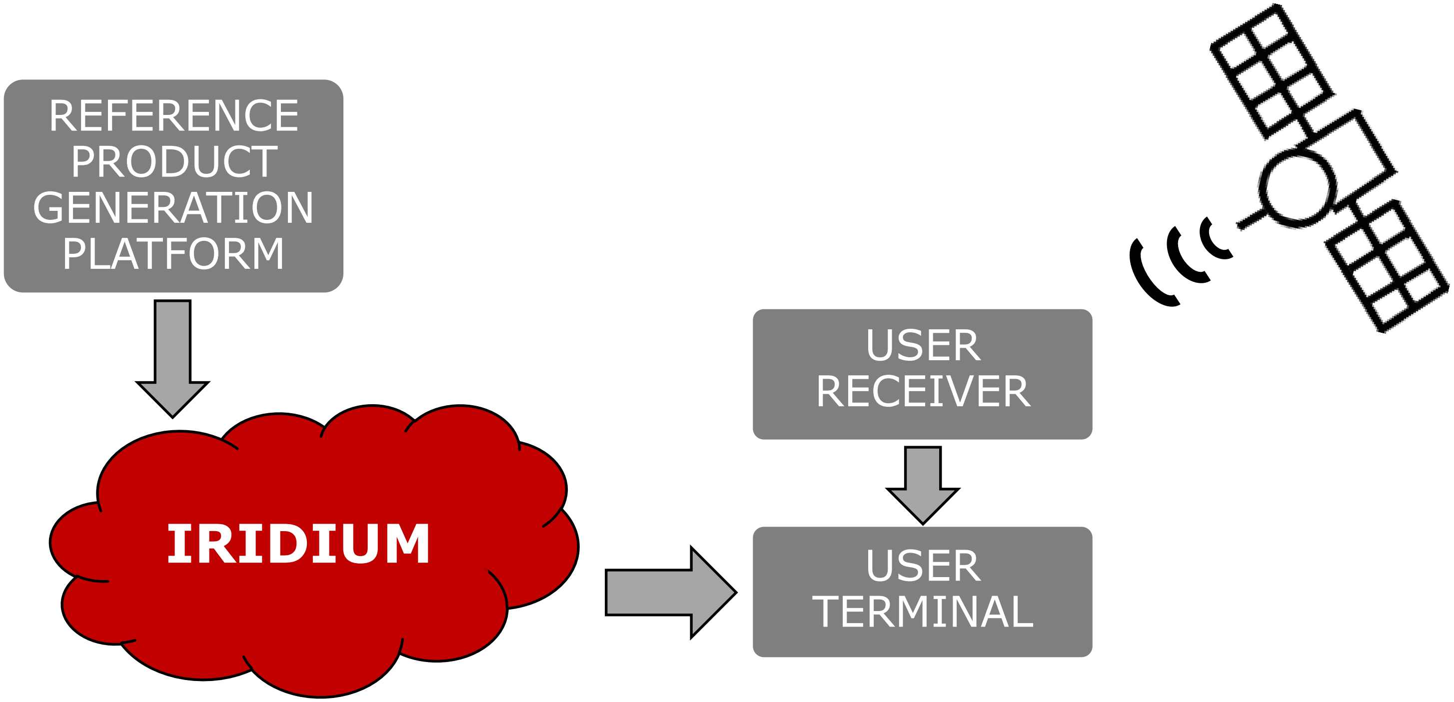
  – Adapt the RTCM-SSR standard to accommodate for proprietary messages

- **Rate of corrections**: 15 min for orbits, 1 min for clocks, 1 min for ambiguity-fixing biases

PRECISE PRODUCTS DISSEMINATION (2)

- RTCM messages suitable to be sent over radio or internet. The NTRIP standard has been specifically developed to broadcast RTCM corrections over the internet. NTRIP stands for an application-level protocol streaming GNSS data over the Internet

- Internet not always available -> User terminal designed to support multiple transmission channels



PPP MESSAGES OVER IRIDIUM

- Iridium is used when no internet is available for NTRIP corrections retrieval

- Constellation of 66 SV (6 planes) in polar orbit, height of 780 km. Worldwide voice and data communication from hand-held satellite phones and other transceiver units

- Iridium network covers the whole Earth, including poles

- 1610.0-1626.6 MHz frequency band operation

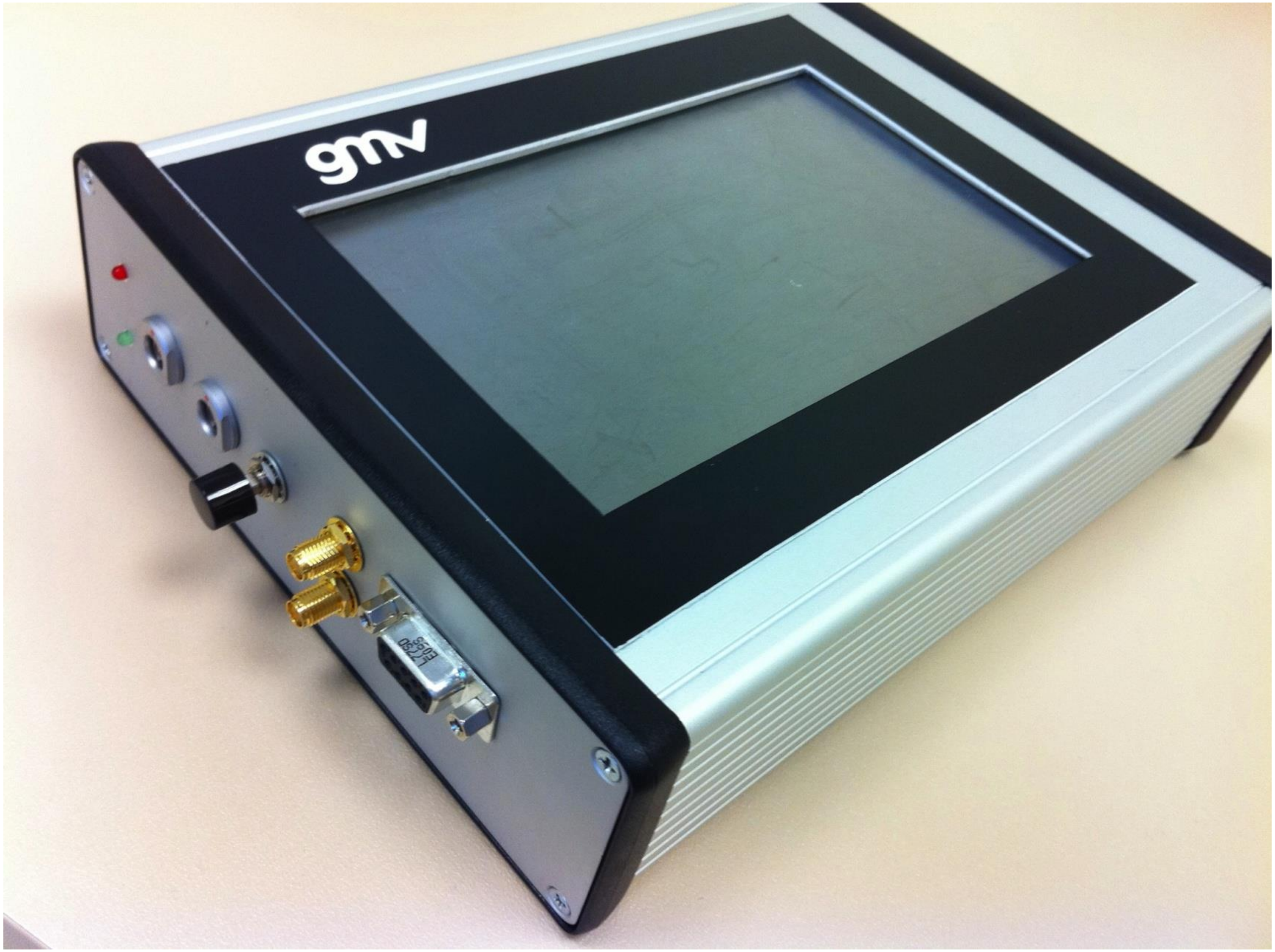
- For PPP the Iridium Short Burst Data (SBD) service is used, which allows two-way communications to a mobile transceiver

- Iridium 9602 modem has been selected due to small size and low power consumption

- <u>Rate of PPP correction messages is the same as in RTCM/NTRIP version</u>: 15 min for orbits, 1 min for clocks, 1 min for ambiguity-fixing biases -> No performance degradation expected due to correction transmission method.

USER TERMINAL OVERVIEW

- On/off LED
- LED for Iridium coverage
- Ethernet socket (for maintenance and debugging)
- Power socket
- On/off button
- SMA connector for GSM antenna
- SMA connector for Iridium antenna
- RS-232 serial port for GNSS receiver (navigation messages and raw measurements)
- LCD touchscreen



PHASE AMBIGUITY RESOLUTION (1)

- *Traditional* PPP does not provide integer carrier-phase ambiguity resolution; in practice this limits PPP accuracy to around 10 cm in horizontal for short arcs (< 1hr)

- Reason: ambiguities are integer up to biases per satellite and receiver; satellite biases can be cancelled by differencing between two receivers (RTK) but PPP has a single receiver

- Ambiguity resolution or *fixing* in PPP would allow for cm-level positioning (all over the Earth!)

- **Solution for PPP**: since satellite biases cannot be cancelled with a reference station, they must be broadcast to the user (apart from orbits and clocks)

- GLONASS ambiguity fixing currently not supported due to inter-channel biases in the receiver

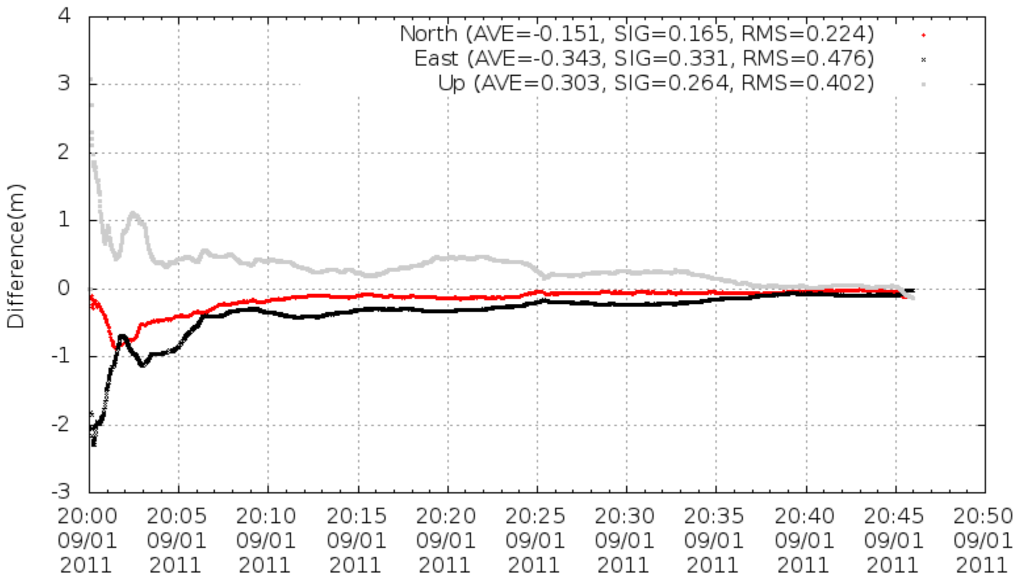
PHASE AMBIGUITY RESOLUTION (2)

- Traditional PPP real time technique requires rather long convergence time due to the ambiguity estimation (filtering) problem

- Convergence time over 30 min for decimeter-accuracy

- Centimeter-level accuracy can only be achieved after many hours

- The example below shows behavior of traditional PPP without ambiguity fixing



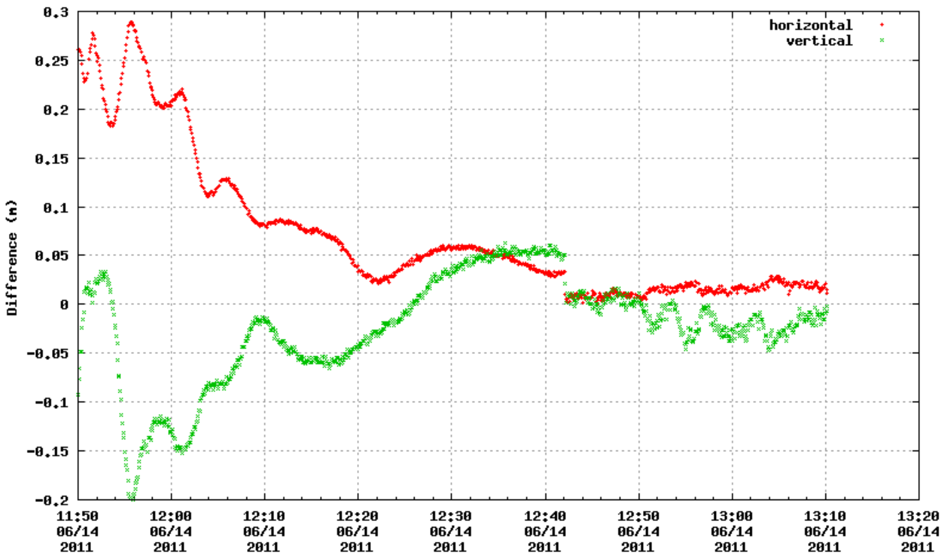
PHASE AMBIGUITY RESOLUTION (3)

- PPP with ambiguity resolution converges to 1-2 cm error (horizontal) after 30 min (as opposed to decimeter-level in traditional PPP)

- A clear jump can be seen in the position error when ambiguities are fixed, typical pattern is shown below

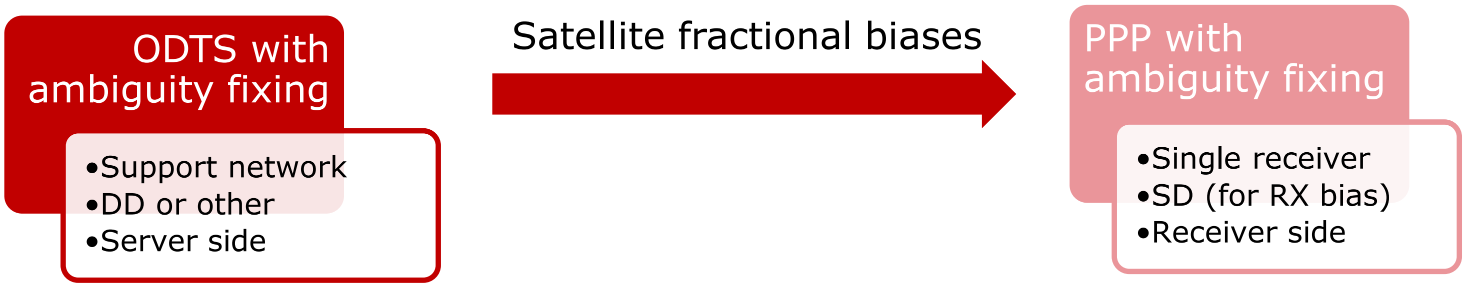
- Decimeter-level accuracy is achieved typically after 10-15 min only

- There is a big room for improvement in convergence time using advanced ambiguity searching techniques -> **GMV target**: Achieve convergence after 5 min



PHASE AMBIGUITY RESOLUTION (4)

- **Ambiguity fixing for PPP**:
  - Station network used to generate orbits and clock corrections is available
  - ODTS with ambiguity fixing and/or dedicated process to estimate satellite **fractional biases**
  - Transmit satellite biases (with orbit + clock corrections)
  - User -> fix integer ambiguities by subtracting biases first



CONCLUSIONS

- Real time products (orbits and clocks) already being generated by GMV

- Algorithms being upgraded to support real-time PPP with ambiguity resolution to enhance convergence time to a few minutes.

- Still large room for convergence improvement using advanced ambiguity searching techniques (GMV target is 5 min)

- Space-State Representation (SSR) in RTCM standard must be adapted in order to accommodate additional biases for ambiguity fixing

- PPP corrections broadcast is RTCM/NTRIP over mobile internet, or by Iridium SBD (Short Burst Data) service in areas with no mobile internet

- Prototype user terminal is being developed by GMV for worldwide RT PPP

- Receiver independent device -> can be connected to any professional GNSS receiver through RS-232 serial port. Supports GSM and Iridium connectivity

Thank you

Guillermo Tobías

GMV GNSS Department

gtobias@gmv.com

Visit us at booth **222/224**

gmv INNOVATING SOLUTIONS