SENSORS I SESSION

Improving Accuracy and Redundancy with GPS and GLONASS PPP

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Abstract
Developments in satellite positioning technologies have seen continual improvements in the robustness and accuracy which is a key requirement in dynamic positioning. Precise Point Positioning (PPP) is a positioning technique developed over the last decade which is used extensively throughout the industry to deliver decimetre accuracy on a global basis.

PPP is an absolute positioning technique which corrects or models all Global Satellite Navigation System (GNSS) error sources such as satellite orbit, satellite clock, troposphere, ionosphere and multipath. The advantage of the PPP technique is that it consists of a single set of ‘globally applicable’ corrections to the satellite orbits and clocks which means that position accuracy is maintained regardless of user location.

Primarily, the GPS system has been used exclusively for satellite positioning due to the fact that it has been the only system with sufficient satellites available to allow continuous positioning. However, that is changing with the replenishment of the Russian GLONASS system which is gradually moving towards a full constellation of operational satellites.

To date, VERIPOS has used GLONASS corrections as part of it Differential service but with the continual increase in the number of satellites, VERIPOS has now integrated GLONASS into its PPP solution.

This paper will look at the experience of integrating both GPS and GLONASS into a PPP solution which provides global decimetre accuracy. It will present a technical overview of the system from the development of an orbit and clock determination system (OCDS) through to the implementation of user algorithms. The paper will also consider the benefits of a multi-constellation PPP for the user and present positioning results demonstrating the accuracy of the system. Benefits that the user will see is improved availability through more satellites, better accuracy and reliability of the position solution and the possibility of independent position solutions.

Also considered is the fact that currently the visualisation of satellite positioning systems in many cases assumes a GPS-only position is derived. To ensure that users can benefit from the advances in GNSS systems, through use of multi GNSS constellation solutions and independent GNSS constellation solutions, the DP and the service providers have to work together to optimise the interfaces between their systems.
Precise Point Positioning

- Absolute positioning technique
  - Used as a real-time system delivering decimetre results
  - Used in offshore positioning for over 10 years
- Correct or model all GNSS error sources
- Single set of orbit and clock corrections for the satellite constellation
  - Valid globally, so position accuracy is maintained regardless of user location
  - Recently seen the addition of GLONASS due to rejuvenation of constellation

Typical PPP Accuracy

- Typical accuracy of PPP using GPS
GLONASS – Why?

- GLONASS is a viable constellation (again!)
  - Significant investment in system
  - Operational system (unlike Galileo & COMPASS)
  - Current constellation is 24 satellites (last launch 09/02/10)
  - Receiver technology much improved
  - Modernization plan (signals, geodesy etc.)
  - Independent positioning system to GPS

What is Needed to Deliver a PPP Solution

- Global Network of Stations
  - Raw GNSS data required for OCDS to calculate orbit and clock corrections to the satellites
  - Upgrade network to track GLONASS

- Orbit and Clock Determination System (OCDS)
  - Processing to calculate orbit and clock corrections

- Formatting and Scheduling of Augmentation Data
  - More data means addition messages

- Data Delivery to User
  - Same techniques but more data being transmitted
  - RTCM NTRIP delivery via Internet

- User/Mobile
  - Upgrade algorithms to handle GLONASS
Orbit and Clock Determination

- This is the core requirement for providing a PPP solution
- System takes in the raw GNSS measurement data from all VERIPOS reference stations
  - From primary and secondary receivers at the site
- Data is managed and processed to calculate orbit and clock corrections
  - Additional data needed includes satellite info (health, etc.) and station info (coordinates, ocean loading, etc.)
- Data input and output is monitored to check performance and ensure that enough redundancy is in the system
- Why develop your own OCDS??
  - Independence and flexibility (e.g., addition of other satellite systems)
  - Ability to control development - improvements to orbit and clock determination to derive higher accuracy orbits and clocks
  - Derive additional monitoring capability particularly of the GNSS networks

OCDS System Architecture

- OCDS has 3 components
  - System Control & Monitoring
  - Orbit and Clock generation
  - Reference station raw data management
- High Accuracy Service Server (HASS) is required to process the multiple formats and streams to the format that will be readable for HUBS
- HUBS sequence the data and send to satellite uplink sites
Issues with GLONASS

- Navigation messages
  - Satellites missing and/or excluded
  - Bad/wrong messages
  - Channel changes without prior warning!

- Time systems
  - GLONASS and GPS used different time systems

- Data cleaning issues
  - More problematic for GLONASS than GPS

- GLONASS orbit model
  - Important for the orbits predictions
  - Area for improvement

- GLONASS phase centre variations
  - Area for improvement

System Monitoring Plots
Network Control Centre

- Control & monitoring of OCDS
- Monitoring integrity of data network
- GNSS integrity monitoring

- Redundant Systems
- Real-Time Monitoring of orbit and clock corrections

Additional Benefits
Delivery of Data to Users

- Typical delivery is via redundant geostationary satellites
  - Provide global coverage
- How do you deliver the data
  - Orbit corrections change slowly over time compared to satellite clocks
- To increase accuracy and minimise impact on bandwidth
  - Transmit orbits and clocks separately
  - Clocks transmitted at a higher rate than orbits
  - Also aids convergence of position solution

NTRIP Delivery of Data to Users

- More clients requesting delivery of corrections via the internet
  - Particularly new builds where no Inmarsat terminals installed
- NTRIP - Network Transport of RTCM via Internet Protocol
  - RTCM Standard
- RTCM data supplied by this service is identical to that broadcast via geostationary satellites
- Supports mass usage as hundreds of data streams can be transmitted to thousand’s users
- Main issue is control of delivery as service providers have no control of data once it leaves their network
  - Delivery to vessel depends on vessel’s Internet delivery system (e.g. KU band)
  - Implementation of monitoring software to confirm that the data has left network
User/Mobile

- Algorithms need to handle both GPS & GLONASS
- Ensure models to correct GNSS errors are the same as those used in the OCDS
- Existing industry standards and guidelines need to be updated to reflect multiple constellations
  - RTCM standard and UKOOA guidelines being updated
- No specific provisions for multi-constellation and high accuracy GNSS systems
  - Independence
  - Quality
  - Consistency

Positioning Performance @ Catu, Brazil

![Graph comparing GPS and GPS + GLONASS positioning performance]

- GPS
- GPS + GLONASS

MTS Dynamic Positioning Conference
October 12-13, 2010
Positioning Performance @ Kristiansund, Norway

Benefits to DP Operators

- Why use multiple Global Navigation Satellite Systems?
  - More satellites providing better availability
  - Remove single points of failure
  - Improved error detection & rejection
  - More signals at different frequencies aids resilience to potential interference
  - Better accuracy when new or modernised signals become available
  - Potential to use each system independently or in a combined solution

- Implications of additional GNSS
  - Increased complexity of different modes of GNSS system operation
  - How to achieve visibility on performance and independence of different GNSS systems?
  - New data interfaces into DP systems
Existing Integration into DP Systems

- No universally adopted standard or message formats within DP systems
- Existing industry standards and guidelines are out of date
- No specific provisions for multi-constellation and high accuracy GNSS systems
  - Independence
  - Quality
  - Consistency
- Most common interface between GNSS system and DP system: NMEA-0183
- Limited status information in NMEA GGA sentence
  - Time & Position
  - Number of satellites (limit is 12)
  - HDOP
  - Correction latency

Improved Integration into DP Systems

- Additional information would benefit DP systems
  - Solution independence – GNSS, solution type information
  - GNSS satellite counter - number of satellites for each GNSS constellation
  - Ability to weight independent solutions appropriately – quality information

- Such information requires a new data interface with DP systems
  - Upgrade of existing standards?
  - Or, proprietary interfaces?

- Opportunity to visualise additional information in DP systems
  - Calculation type (GPS-only, GLONASS-only, GPS+GLONASS etc)
  - Number of GPS / GLONASS / GALILEO satellites
  - GNSS PosRef quality