

# G-Nut software library for implementing various GNSS applications

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## Abstract

The poster presents current state of G-Nut software library for GNSS analyses. This software is being developed at the Geodetic Observatory Pecny (GOP) since January 2011. The main goal of the library is to support the implementation of various end-user programs fitting to specific applications such as GNSS observation data manipulation and quality checking, PPP-based processing for high-rate kinematic or static solution, ultra-fast or near real time troposphere estimation, but also for providing services for estimation satellite clock or other products based on a network of stations. All library models are designed for the use of undifferenced multi-GNSS data. The core library structure supports both real-time (off-line, online) and post-processing modes using RTCM correction and precise orbits and clocks in SP3 and CLK RINEX. We present some details on the implementation of the core library structure as well as example results from the first applications for PPP positioning and real-time troposphere estimation.

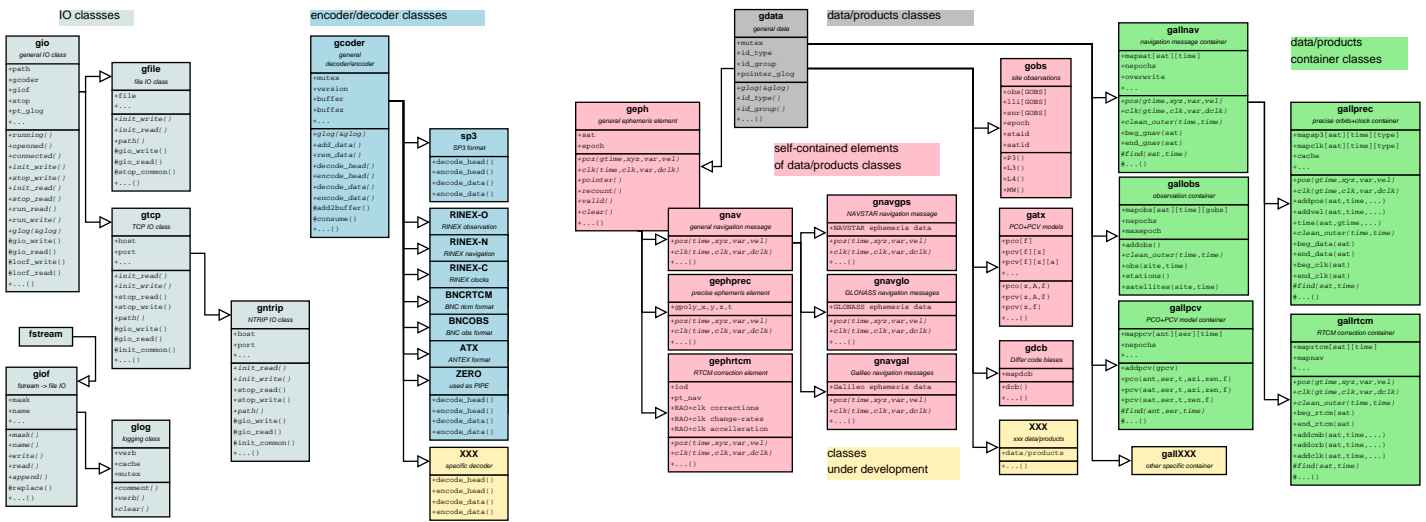
## G-Nut software library



The G-Nut library is being developed in ANSI c++ with the main goal to provide a platform for easy implementing various individual applications. Currently, the G-Nut depends only on the external Boost library using its cross-platform thread implementation and asynchronous and synchronous IO operations (asio). The intention is to keep the core library independent from any large framework and to keep it relatively small and flexible for various current and future aims. The main characteristics can be summarized as follows:

- object-oriented, thread-saved design for multi-threaded applications
- currently support linux and windows platforms
- flexible design to support various application and adaptable structure for future extensions
- data and product container classes support both real-time and batch post-processing solutions
- flexible IO classes supporting various input/output strategies
- various adjustment models (LSQ, SRIF, Kalman, back-smoothing, ...)
- multi-GNSS support (GPS, GLONASS, Galileo,...)
- flexible configuration is being developed taking advantage of XML format

## Object-oriented class design of G-Nut core library



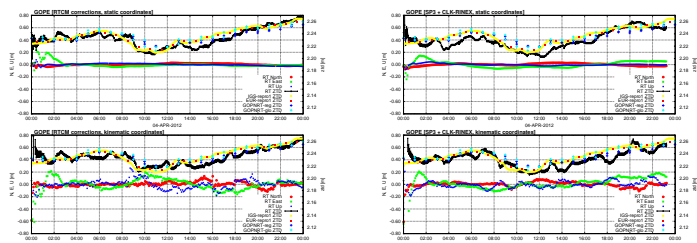
IO classes (grey background): classes for all inputs and outputs. Coders classes (blue background): encoding/decoding various data, models or products. Virtual data classes (dark green background): base for all data. Data containers (green background): containers of all GNSS data such as observations, orbits etc.. Autonomous data/product element (pink background): one item in data container.

## Application testing and results

One of the first application of G-Nut library is a Precise Point Positioning tool. It has been implemented for real-time and post-processing modes and supporting static or kinematic solutions. For real-time we currently use BKG Ntrip Client (BNC) as a feed engine for input raw real-time GNSS data and products, but we plan to include open-source drivers directly. In the post-processing the package is able to process RINEX data supported by precise orbits in SP3 format, precise clock corrections in RINEX format and PCO+PCV models in ATX format. We are ready to estimate station coordinates, receiver clocks and zenith tropospheric delay (currently with float ambiguity only). Coordinates and receiver clocks are designed as white noise stochastic model and ZTD as random walk process. Stochastic behaviour is possible to set in XML configuration file. According to white noise value, we distinguish between static and kinematic solution. Static solution has zero white noise (we can call constant model) and in kinematic solution white noise differs from zero. Results from such solutions are shown below.

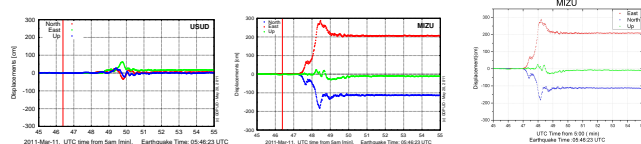
## Real-time and off-line ZTD estimation

Zenith total delay were estimated in 'simulated' real-time over 44 days (using RTCM corrections, left plots) and post-processing (using SP3 and CLK-RINEX, right plots) mode together with estimating static (top) and kinematic (bottom) coordinates for station GOPE. The IGS-, EUREF-repro1 and GOP NRT products are plotted for the troposphere comparisons.



## High-rate earthquake detection

Kinematic solution is able to detect deformation effects, e.g. strong earthquakes, land-slides etc. The IGS stations USUD (left plot), MIZU (center plot) were processed in 1Hz during Tohoku-Oki earthquake in Japan (2011). MIZU solution is compared with results from Wuhan university in China by Ronxin et al (right plot).



## Conclusion and outlook

This suit of applications as command-line programs is currently available:

- **gNut-Geb** – client for real-time or post-processing precise point positioning and coordinate monitoring
- **gNut-ntrip-client** – collects stream from NTRIP caster to a file
- **gNut-ntrip-server** – rotates file content to NTRIP caster as a stream
- **gNut-ntrip-pipe** – NTRIP pipe including threads of client and server forwarding any stream from one NTRIP caster to the other

The following applications are planned to be developed or converted from the existing GOP in-house implementations with a support of new G-Nut core library:

- **gNut-Tefnut** – client for real-time or post-processing troposphere parameter estimation
- **gNut-NavMonitor** – concatenates and checks navigation messages, estimates GPS manoeuvres, converts to SP3 format
- **gNut-RnxMonitor** – checks the content of the observations in RINEX format (new features are planned according to the quality check, file concatenation, header manipulation etc.)
- **gNut-OrbMonitor** – compares, converts or streams precise orbits.

Primarily, our development has been focused on a core library and the first PPP solution. However, a network solution for satellite clock correction and bias estimations as well as up-to-date developments concerning PPP technique are foreseen in near future keeping a high priority on a multi-GNSS support.

Up-to-date information about the library will be maintained on the web page:

<http://pecny.asu.cas.cz/> (GNSS, software).

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