# IVG::ASCOT: The Development of a new VLBI Software Package

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## Introduction

There are several VLBI analysis packages around. However, there are quite good reasons to start developing your own software. At the Institute of Geodesy and Geoinformation (IGG) of the University of Bonn, the main goal is to have a flexible and expandable environment at hand to easily develop new scientific projects. This is merely the case for present packages due to internal structures or the dependence on proprietary or non-free libraries or programs, e.g., MATLAB or INTEL's fortran compiler. Thus, the IGG VLBI group (ivg) started the developement of the Analysis, Scheduling, and Combination Toolbox (ivg::ASCOT) in December 2014. The programming language is C++ and for the graphical user interface Qt (`http://www.qt.io/`) is used. The basis are the IERS Conventions 2010 [8] where the FORTRAN routines (`http://62.161.69.131/iers/convupdt/convupdt.html`) are compiled into a library and directly linked. Furthermore, the SOFA library (`http://www.iausofa.org/`) is used for the Earth orientation, and the CSPICE toolkit (`http://naif.jpl.nasa.gov/naif/`) or code from ProjectPluto (`http://www.projectpluto.com/jpl_eph.htm`) is used for handling the JPL emphemeris. For the numerical calculation, we make use of ATLAS/LAPACK (`http://math-atlas.sourceforge.net/` and `http://www.netlib.org/lapack/`) or openBLAS (`http://www.openblas.net/`).

Currently, a basic VLBI data analysis in a session-by-session mode is possible. Furthermore, a global solution on pre-processed and pre-reduced datum-free normal equations in SINEX format can be performed, which ends up in a combination on the normal equation level, as performed by the IVS Combination Center.

## Strategy

### Independent solution

- input: vgosDB data format or NGS card files
- station motions: IERS Conventions, and further variations, e.g., non tidal atmospheric pressure loading [9]
- theoretical delay & relativistic corrections: IERS Conventions
- EOPs from IERS C04 or USNO finals & subdaily variations: IERS Conventions
- stochastic modeling: correlator output & additional weighting: constant/elevation dependent/from turbulence theory [3]
- parameterization: polynomial & continuous piece-wise linear
- output: datum free normal equations & solution with covariance matrix

### Global solution

- input: SINEX data format
- reduction of nuisance parameters
- a priori transformation
- transformation, manipulation and addition of normal equations [1]
- session by session combination on the normal equation [2] or solution level [4]
- output: solution with covariance matrix

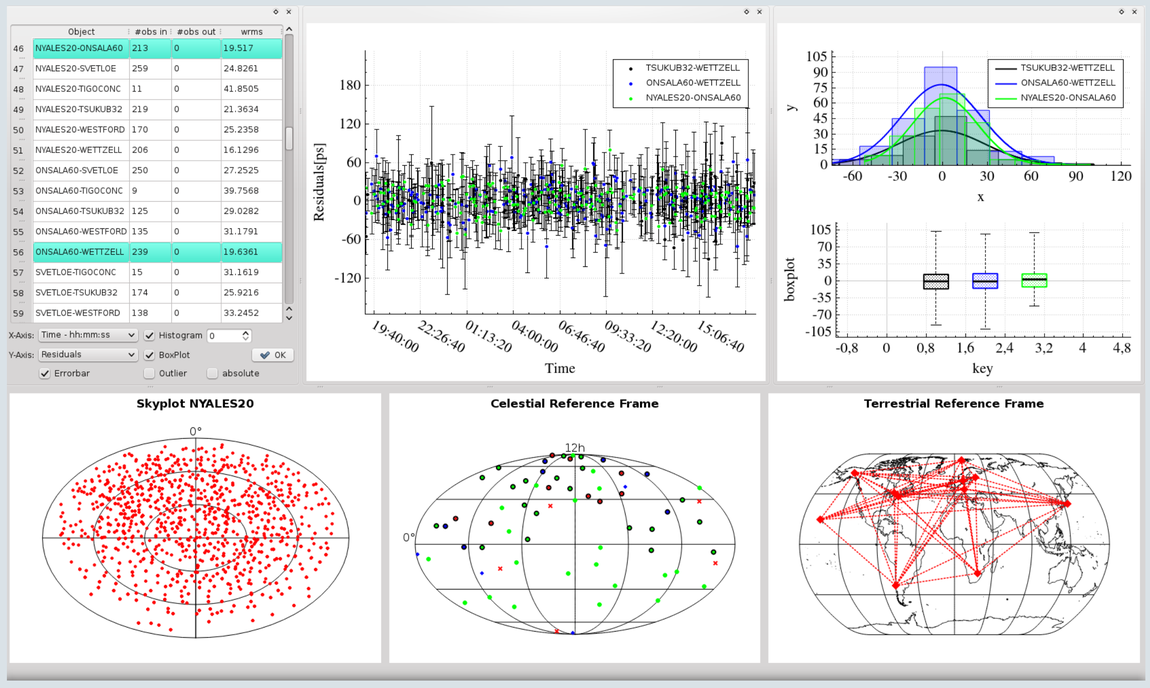
### Scheduling

- input: SKED catalogs
- currently not integrated in ivg::ASCOT, but standalone program
- methodology: SVD [7]
- output: skd-files

### Simulation

- input: vgosDB
- baseline dependent noise
- clocks: power-law processes [5]
- troposphere: based on turbulence theory [6]

## Independent Solution



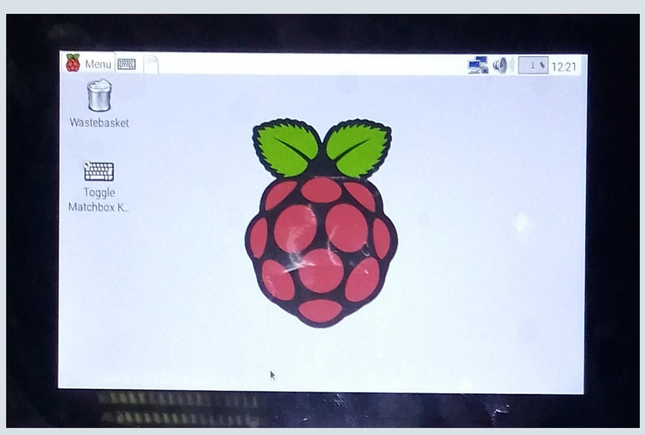

- polynomial and continuous picewise linera representation
- elimination of outliers (data snooping, Baarda test)
- plotting of residuals
- statistical analysis of residuals, e.g., histogram and box plot
- selection by stations, baselines and sources
- skyplots
- planned: time series analysis in spectral domain

## Try ivg::ASCOT yourself - Live

Since ivg::ASCOT is based on a well-conceived design and concept, the installation and using is straightforward.

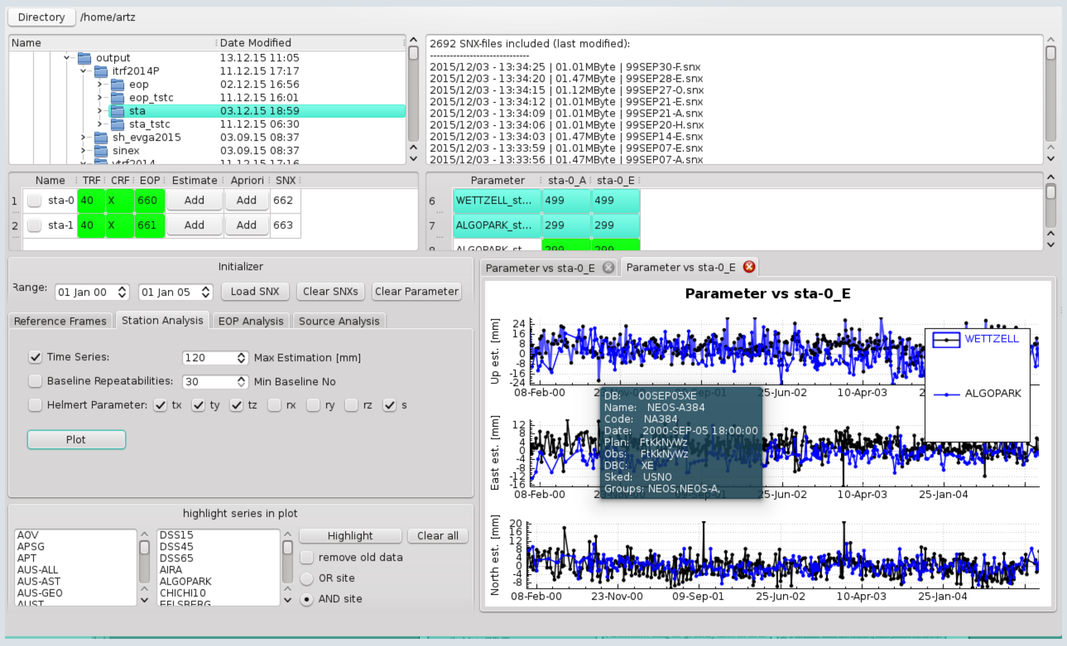
Try and convince yourself by choosing one of the supported features, linked on the desktop:

- Terminal-Modus: start a VLBI analysis from command-line and perform a residual analysis
- Interactive-Modus (beta): use an interactive GUI to analyze a VLBI session
- SNX-Analyzer: investigate generated results based on SINEX files




## Analysis GUI

- input: SINEX files
- visualization of time series:
  - stations,
  - sources,
  - EOP
- highlighting sessions of specific type or with specific stations
- tooltips
- plot TRF and CRF
- estimation of Helmert parameters and investigate residuals
- planned: time series analysis based on current plot




## Conclusions

The implementation of ivg::ASCOT is done in C++, and thus, highly flexible and expandable. Furthermore, using the Qt-library allows for an intuitive and easy way to create graphical user interfaces. At the present stage of the developement, typical VLBI parameters can be estimated in an independent solution, and basic time series analysis can be performed on residuals and estimates. Furthermore, the global solution can be used to estimate celestial and terrestrial reference frames, and, even a combination of various analysis centers is possible.

Although yet not integrated, the scheduling part is based on the ASCOT-libraries. This scheduling program is used to schedule the INT2 sessions.

Currently, the theoretical modeling is assessed in the VLBI Analysis Software Comparison Campaign (see talk of G. Klopotek). Further developements will be primarily based on themes of phd-theses.

## References

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