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# Some Features of Pre-Processing of RTK Network LitPos (Lithuania) Data Applying Bernese Software

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**Abstract.** LitPOS (Lithuanian Positioning System), the network of permanent reference GNSS stations, became operational in July 2007. It provides data both for real-time and post-processing applications. LitPOS stations cover the whole territory of Lithuania. Total number of LitPOS GNSS stations during 2007–2014 period was 25 (since 2015 – 30 stations). Also LitPOS network includes 3 ASG-EUPOS (Poland) and 6 LATPOS (Latvia) stations. LitPOS network data re-processing was done using Bernese (BSW5.2 update 2016 01 08) software. Software was slightly improved by editing scripts and writing procedures for RINEX files preparation, for downloading other necessary data, and for getting two processing solutions from single BPE (Bernese Process Engine) process (total network and sub-network without Polish and Latvian stations).

**Keywords:** LitPOS, RTK network, LitPOS data pre-processing, Bernese 5.2.

**Conference topic:** Technologies of Geodesy and Cadastre.

## Introduction

The LitPOS (Lithuanian Positioning System) network of GPS reference stations became operational in July 2007 (Paršeliūnas *et al.* 2008; Paršeliūnas *et al.* 2011). LitPOS network stations cover the whole territory of Lithuania. Total number of LitPOS GNSS stations during 2007–2014 period was 25 (since 2015 – 30 stations). In addition, LitPOS network includes 3 ASG-EUPOS (Poland) (Wajda *et al.* 2008; Ryczywolski *et al.* 2008; Bosy *et al.* 2008; Graszka *et al.* 2009; Ryczywolski *et al*. 2010) and 6 LATPOS (Latvia) stations (Dobelis, Zvirgzds 2016; Zvirgzds 2007, 2012; Balodis *et al.* 2009; Haritonova 2012, 2013, 2016; Haritonova *et al*. 2013). LitPOS network data re-processing was done using Bernese (BSW5.2 update 2016 01 08) software (Dach *et al.* 2015).

GNSS observations data pre-processing may be required for metadata correction, time windowing, data splitting or combining and other filtering, perform quality checks prior to re-processing the data. Before starting the reprocessing of 2007–2014 LitPOS network data, Bernese 5.2 software process control file (*NKG_R2Sall.PCF*) was set up using "Guidelines for NKG GNSS AC Re-processing No. 1". The re-processing was executed with the following parameters:

- Cut-off angle: 3°, 10°, 25°;
- Tropospheric refraction: VMF;
- Precise orbits, etc.: CODE;
- GNSS: only GPS;
- Ambiguity resolution strategy: QIF;
- Baselines processing strategy: OBS-MAX;
- ITRF realization:
- EPN_A_IGb08_C1845.SNX;
- Antennas PCV: absolute and individual calibration;
- Fiducial stations used in re-processing: BOR1, RIGA, ONSA, MDVJ, MAR6, WTZR, VLNS, SWKI, VIS0, SVTL (Fig. 1).

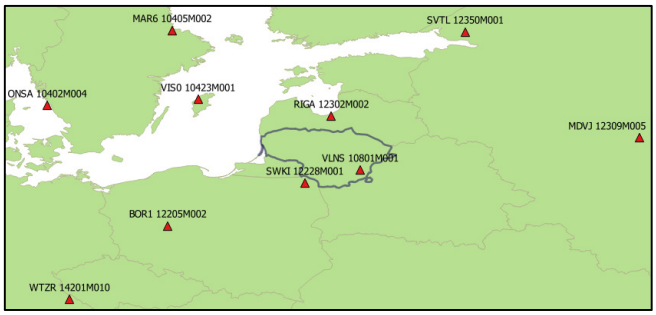


Fig. 1. Fiducial stations

**Initial data preparation**

Since July 2007, LitPOS permanent GNSS network provides data for real-time and post-processing applications. Data are stored to RINEX files from real-time streams using Trimble GPSNet software (till 2015) and TPP (Trimble Pivot Platform) at LitPOS permanent network servers. The format of LitPOS network stations data is RINEX 2.11. The hourly files with 1-second observations interval were stored. Besides RINEX files, hourly files in Trimble binary format T02 are stored as backup for missing observation files.

Before starting 2007–2014 re-processing of LitPOS network data, RINEX files are combined into one daily RINEX file (interval between observations was set to 30 seconds) using *teqc.exe* program and special batch file code. The combining of one-month data of 30 stations takes about 10 hours of computing time.

Other data like a satellite clock file (*.CLK), Earth rotation parameter file (*.ERP), ionosphere file (*.ION), ephemeris file (*.EPH), Differential Code Biases corrections file (*.DCB), Vienna Mapping Function and RINEX files of fiducial stations necessary for reprocessing were obtained from ftp servers using batch file code and *wget.exe* program and were putted into appropriate directories (Fig. 2).

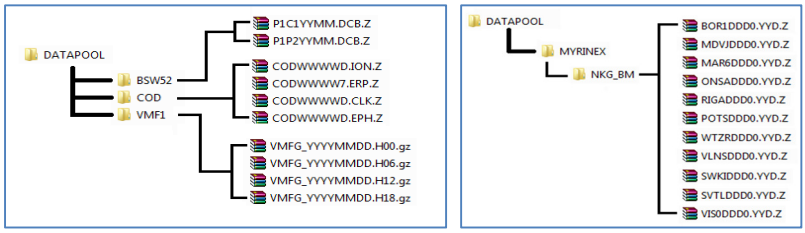


Fig. 2. Scheme of data structure

Downloading of RINEX files of 10 fiducial stations of one year takes about 4 hours, and other necessary files download takes about 2–3 hours of computing time.

**Modifications of PCF file**

The Process Control File (PCF) defines which scripts should be run, and in what order they should be executed. In addition to listing the scripts to run, the PCF file:

- ✓ defines, which scripts must wait for other scripts before they can run,
- ✓ defines parameters, that are to be passed into the scripts,
- ✓ the CPU to be used by the client, and
- ✓ the option panels to be used by the Bernese programs executed in the scripts.

The PCF files are ASCII files. The file consists of three sections (Dach *et al.* 2015):

1. Section defining the sequence of the scripts, option directories and CPUs to be used, and wait conditions (starting with header string PID SCRIPT).
2. Section defining parameters and special actions (starting with header string PID USER).
3. Section defining values for variables passed to the scripts (starting with header string VARIABLE).

Few ADDNEQ2 scripts were added to NKG_R2SALL.PCF file to create additional 3° and 10° solutions with all LitPOS, 6 LatPOS and 3 ASG-EUPOS GNSS stations. In addition, NKG_SAVD script was modified to copy extra solutions to SAVEDISK area (Fig. 3).

```
# ---------------------------
500 MKCLUSAS NKG_FIN          ANY      1 499
#
## Compute ambiguity-fixed network solution, create final NEQ/SNX/TRO files 3 deg
# ------------------------------------------------------------------------------
501 GPSCLUAS NKG_FIN          ANY      1 500
 .....
522 GPSXTR   NKG_RED          ANY      1 521
523 ADDNEQ2  NKG_FI2          ANY      1 522
524 ADDNEQ2  NKG_RE2          ANY      1 523
599 DUMMY    NO_OPT           ANY      1 512 513 514 522 523 524
#
## Compute alternative ambiguity-fixed network solution, create final alternative NEQ/SNX
# ------------------------------------------------------------------------------------------
601 GPSCLUAS NKG_F10          ANY      1 500
 .....
622 GPSXTR   NKG_R10          ANY      1 621
623 ADDNEQ2  NKG_F12          ANY      1 622
624 ADDNEQ2  NKG_R1B          ANY      1 623
699 DUMMY    NO_OPT           ANY      1 612 613 614 622 623 624
 .....
# Create summary file and delete files
# ------------------------------------
901 NKG_SUMe NKG_GEN          ANY      1 599 699 799
902 NKG_SAVD NKG_GEN          ANY      1 901
903 NKG_DEL  NKG_GEN          ANY      1 902
904 OBS_DEL  NKG_GEN          ANY      1 903
991 BPE_CLN  NKG_GEN          ANY      1 904
#
# End of BPE
# ----------
999 DUMMY    NO_OPT           ANY      1 991
```

Fig. 3. Fragment of NKG_R2SALL.PCF modifications

Local Analysis Centres (Jivall *et al.* 2005, 2007, 2013; Häkli *et al.* 2016; Bruyninx *et al.* 2013; Lidberg *et al.* 2013) process their subnetworks using the strategy specified in the Guidelines for the Analysis Centres and submit coordinate and troposphere solutions in the SINEX and Troposphere SINEX formats (IERS 2006). The SINEX files contain complete information about the GNSS network solution (estimated geodetic coordinates and coefficients of normal equations or covariance matrix) and they are used as a basis to compute the weekly combined EPN solution (Weekly combined solutions... 2017).

To improve the flexibility of weekly solution preparation to NKG_ADD.BAT (author Lotti Jivall) file the additional commands were added allowing users to define the number of weeks for processing at once (Fig. 4).

```
rem     Lotti Jivall  20140714↓
rem     updated:  ↓
rem     2015-05-08: Added mame changing for NKG GNSS AC: LM_wwwwd?.CRD/SNX
rem +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
    SET WEEK0=1485↓
    SET WEEKS=2↓
↓
        SET KAMPANJ=VGTU↓
        SET NAME=LIT↓
↓
    SET /A WEEK1=%WEEK0% + %WEEKS% -1↓
↓
setlocal enabledelayedexpansion↓
FOR /L %%d IN (%week0%,1,%week1%) DO (↓
↓
        SET GPSWEEK=%%d↓
    echo !GPSWEEK!↓
↓
rem +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
rem No more parameters↓
```

Fig. 4. Fragment of NKG_ADD.BAT file modifications

Also to LM_ADD.PCF file was added the script to transform weekly solution geodetic coordinates to ETRS89 frame (Madsen, F., Madsen, B. 1993; Ehrnsperger 1995; Kenyeres 2012) (Fig. 5).

```
# Copy required files
# -------------------------------------------------
001 NKA_COP  NKG_GEN            ANY      1
002 CRDMERGE N03_ADD            ANY      1 001
003 CRDMERGE N10_ADD            ANY      1 002
#
# Run combined solution weekly solutions 3, 10 and 25 deg
# -------------------------------------------------------
100 ADDNEQ2  N03_ADD            ANY      1 003
110 ADDNEQ2  N10_ADD            ANY      1 100
120 ADDNEQ2  N25_ADD            ANY      1 110
#
# Helmert-transformations
# -------------------------------------------------------
200 HELMR1   N03_ADD            ANY      1 120
210 HELMR1   N10_ADD            ANY      1 200
220 HELMR1   N25_ADD            ANY      1 210
230 ETRS89   N03_ADD            ANY      1 220
  ■ ■ ■
# -------------------------------------------------------
320 LIT_SUM  N03_ADD            ANY      1 310
330 LIT_SU2  N10_ADD            ANY      1 320
#
# End of BPE
# ----------
400 LM__SAVW NKG_GEN            ANY      1 330
991 BPE_CLN  NKG_GEN            ANY      1 400
999 DUMMY    NO_OPT             ANY      1 991
```

Fig. 5. Fragment of LM_ADD.PCF modification

**Tracking of inconsistencies**

A summary of all available observation data is created giving a complete overview of observed satellites, involved stations and their performance. This file appears in the processing summary and may help to identify possible data tracking problems of observing sites (Dach *et al.* 2015).

Summary files of daily solutions contain information about data, errors, inconsistencies, results etc. For example, the inconsistency of antenna type presented in the station information file STA and in the RINEX header is shown in Fig. 6.

```
SVNL 10823M001    TRIMBLE 5700          TRM41249.00     NONE      0.0000 m                                          #OK↓
SVTL 12350M001    TPS NETG3             TPSCR.G3        TPSH      0.0285 m                                          #OK↓
SWKI 12228M001    TRIMBLE NETR5         TRM55971.00     TZGD      0.0000 m                                          #OK↓
TAUR 10824M001    TRIMBLE NETRS         TRM39105.00     NONE      0.0000 m                  TRM41249.00     NONE    #Problem↓
TELS 10825M001    TRIMBLE 5700          TRM41249.00     NONE      0.0000 m                                          #OK↓
UTEN 10827M001    TRIMBLE NETRS         TRM29659.00     NONE      0.0000 m                                          #OK↓
VARN 10828M001    TRIMBLE 5700          TRM41249.00     NONE      0.0000 m                                          #OK↓
VEIS 10829M001    TRIMBLE NETRS         TRM29659.00     NONE      0.0000 m                                          #OK↓
VGTU 10830M001    TRIMBLE NETRS         TRM29659.00     NONE      0.0000 m                                          #OK↓
VIS0 10423M001    JPS EGGDT             AOAD/M_T        OSOD      0.0710 m                                          #OK↓
VLNS 10801M001    ASHTECH Z-XII3        ASH700936A_M    NONE      0.0730 m                                          #OK↓
WTZR 14201M010    LEICA GRX1200GGPRO    LEIAR25.R3      LEIT      0.0710 m                                          #OK↓
```

Fig. 6. TAUR 10824M001 station antenna name inconsistency

A script created by S. Nyberg was used to produce SINEX Check files (*.snxchk). These files contain information about inconsistency of SINEX, station information and antenna phase center corrections files. The inconsistency of station receiver and antenna types presented in the SINEX and STA files during weekly combination processing is shown in Fig. 7.

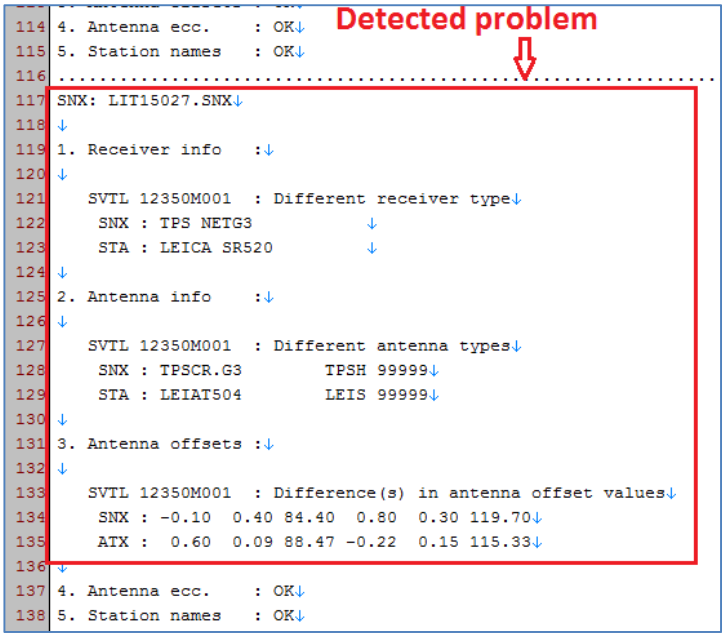


Fig. 7. SVTL station receiver and antenna type mismatch

**Conclusions**

1. Some slight improvements of the scripts were done to adjust the automated pre-processing and re-processing of LitPOS data to users needs. In order to automate downloading of necessary initial files from ftp servers a batch file was created employing wget.exe program. To improve the flexibility of weekly solution preparation a batch file was modified by adding commands, which allows users to define the number of weeks to be reprocessed at once.
2. The inconsistencies of different type were detected and removed from the LitPOS data to process the final solutions of LitPOS network based on stations absolute antenna models, 3°, 10° and 25° cut-off angles by Bernese 5.2 software and applying the initial parameters from NKG guidelines.

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