Curtin and Delft Multi-GNSS M-GEX Stations: Infrastructure and Analysis Tools

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ABSTRACT The GNSS Research Centre at Curtin University and the Department of Geosciences and Remote Sensing at Delft University of Technology are contributing as the Australian and Dutch data providers and as a joint Experiment Analysis Centre in the International GNSS Service Multi-GNSS EXperiment (IGS M-GEX) campaign. In this poster, we present the details of Curtin's and Delft's continuously operating multi-GNSS M-GEX stations, their data streams, and the analysis tools used in the experiment. The stations have several high-grade GNSS receivers capable of tracking all GNSS systems and observation types. The capabilities of these receivers and antennas, monumentation of antennas, data archival and real-time streaming regimes available to the IGS community are described and summarised in the poster. The developed multi-system GNSS data validation, conversion and analysis tools used in the experiment are also discussed. Access details for the real-time and archived data streams and the analysis products are provided.

GNSS INFRASTRUCTURE

The GNSS Research Centre at Curtin University and the Delft University of Technology maintain a number of continuously operating GNSS stations to facilitate their research activities and provide data to regional and international collaborators, for example, to maintain regional reference frames (Asia Pacific Reference Frame [APREF], and European Reference Frame [EUREF]) and for experiments such as IGS Multi-GNSS EXperiment (IGS-MGEX). The GNSS Research Centre and Delft University of Technology also develop and maintain a number of in-house research software besides using off-the-shelf commercial and scientific software. These continuously operating GNSS stations and software are combinely termed as GNSS Infrastructure.

Curtin University GNSS stations are installed on Building 402, which is the highest building in the area, with almost clear 360 degrees visibility. This setup has three stations (CUT00, CUTA0 and CUTB0) with steel masts securely installed to a concrete structure on the roof. GNSS antenna for CUT00 station is shown in Figure 1. Two of these stations (CUT00 and CUTA0) have Trimble TRM 59800.00 geodetic grade antenna with choke ring and SCIS radome. The third station (CUTB0) has a survey grade Javad GRANT-G3T antenna. All of these antennas are capable to receive all available multi-frequency GNSS signals from multiple GNSS (GPS L1/L2/L5 + GLONASS L1/L2/L3 + GALILEO E1/E5A/E5B/E5AB/E6 + QZSS L1/L2/L5/LEX + COMPASS B1/B2/B3). Each of these antennas are connected to one or several GNSS receivers. The GNSS receiver setup and types of observations available for each GNSS receiver are shown in the following Figure 2.

Delft University of Technology GNSS stations are installed on the former Geodesy building, now home of the Netherlands Metrology Institute (NMI). The setup has a number of markers on a specially designed observation platform for geodetic observations. The main station (DLF1-5) is on a 1.5 mast with a LEICA AR25.R3 3D choke ring antenna and is shown in Figure 3. The antenna is connected to a Trimble NETR9 (DLF1), two Javad TRE_G3H Delta receivers (DLF2, DLF3) and a Septentrio PolaRx2 (DLF5). DLF1 and DLF2 support all current GNSS constellations and observations. Several other receivers are operated on the same site by TU Delft (DELF, DLFT) and NMI for time transfer.

Figure 1: Curtin University CUT00 station

Figure 3: Delft University of Technology DLF1-5 station

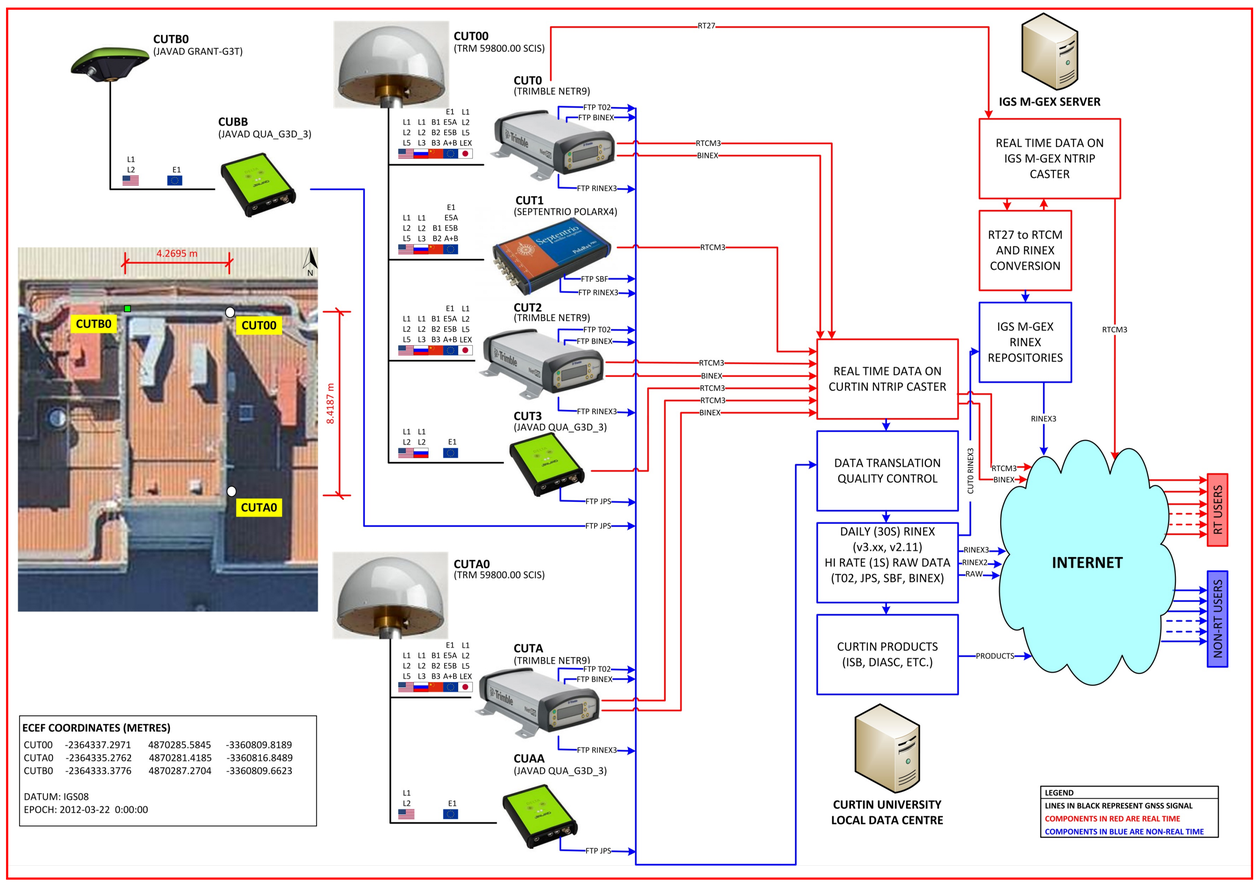

Figure 2: Curtin University GNSS stations and receiver setup, and real-time and non-real-time data Flow

REAL TIME AND NON-REAL TIME (ARCHIVED) DATA AVAILABILITY

Both real-time and non-real-time data are freely available to the GNSS community in compliance with our open-data policy. Real time data from Curtin University are available in RTCMv3 and BINEX formats on our NTRIP caster (saegnss2.curtin.edu.au:2101).

Non-real-time data from Curtin University's local data centre are available at saegnss2.curtin.edu.au/ldc. This data centre contains daily RINEX files (both v2.11 and v3) at a sampling rate of 30 sec and binary data in native formats (T02, JPS, SBF) and BINEX format at a sampling rate of 1 second. The data flow diagram comprising of both real-time and non-real-time data flow for all GNSS stations at Curtin University are shown in Figure 2. Non-real-time data from Delft University of Technology DLF1 station is available on gnss1.tudelft.nl/dgpa in RINEX v3 format at a sampling rate of 1sec (15 minute duration), 10 sec (1 hour duration), and 30 sec (daily). Access details for these data sources are given in Table 1.

In addition to these data sources which are available locally on Curtin and Delft servers, real-time and non-real-time data from GNSS station CUT0 and DLF1 are also available at IGS M-GEX NTRIP caster (mgex.igs-ip.net:2101) and IGS M-GEX data repositories (cddisin.gsfc.nasa.gov, igs.bkg.bund.de and igsdepot.ign.fr). DLF2 at Delft University of Technology is hosted on behalf of JAXA for their Multi-GNSS Monitoring Network (MGM-net) campaign. CUT0 at Curtin University will also participate in JAXA's MGM-net campaign in the near future.

Data	Institution	Address	Access details
Real-time	Curtin University	saegnss2.curtin.edu.au:2101	Contact first author
Non-real-time	Curtin University	saegnss2.curtin.edu.au/ldc	Open access
Non-real-time	Delft University of Technology	gnss1.tufelft.nl/dgpa	Open access

Table 1: Real-time and non-real-time data access details

ANALYSIS UNDERTAKEN FOR MGEX

Data from GNSS stations at Curtin University and Delft University of Technology are used to support, test and validate the research activities at both institutions. GNSS stations at Curtin University in Australia have the advantage of tracking the Japanese QZSS satellite and most of the Chinese COMPASS satellites (MEO, GEO and IGSO). Multi-GNSS data collected at Curtin University, therefore, plays an important role in the IGS M-GEX campaign analyses.

Following in-house analyses tools have been developed at Curtin University and are used for IGS M-GEX analyses.

1. **Inter-System Biases (ISB) estimation between GPS and GALILEO using KALDIA and MC-LAMBDA software [1]:** ISBs are required to be calibrated in order to process multi-GNSS data from different types of receivers. Two independent software (KALDIA and MC-LAMBDA) are used to cross-validate the estimated ISBs between GPS and GALILEO as shown in Figure 4
2. **Data Screening using DIASC software [2]:** This tool performs quality control of GNSS observations using a single-receiver single-satellite undifferenced-observations approach utilizing the DIA Method as shown in Figure 5
3. **Geometry Free Analysis using GFA software [3]:** GFA software developed with Delft University is used to study noise characteristics of multi-GNSS software as shown in Figure 6

More details about these tools and the analyses results are presented at IGS Workshop 2012. More results are also available to the research community upon request.

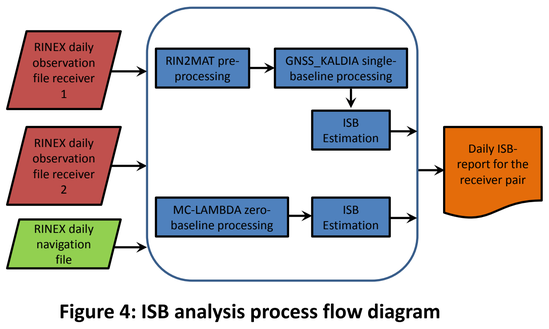

Figure 4: ISB analysis process flow diagram

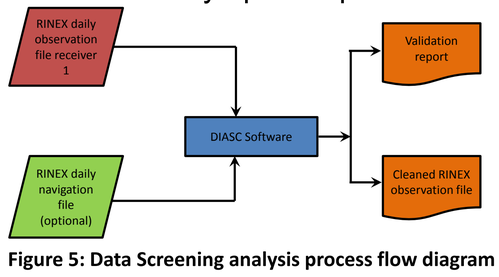

Figure 5: Data Screening analysis process flow diagram

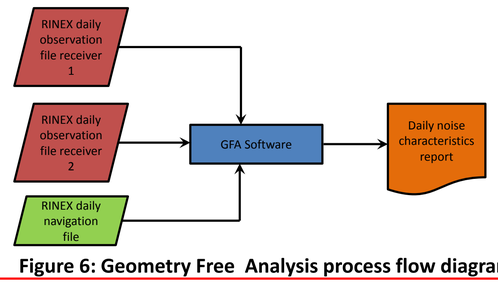

Figure 6: Geometry Free Analysis process flow diagram

REFERENCES

[1] Odijk, D., and Teunissen, P.J.G. (2012): Characterization of GPS-Galileo inter-system biases and their effect on mixed ambiguity resolution. Submitted to GPS Solutions.
[2] El-Mowafy, A., Teunissen, P.J.G., and Odijk, D. (2010): Single-receiver single channel real-time validation of GNSS data. Proceedings of 2010 International Symposium on GPS/GNSS, Taipei, Taiwan.
[3] de Bakker, P.F., Tiberius, C.C.J.M., van der Marel, H., and van Bree, R.J.P. (2012): Short and zero baseline analysis of GPS L1 C/A, L5Q, GIOVE E1B, and E5aQ signals. GPS Solutions, 16(1), 53-64.