



Experience from Multi-GNSS Network Processing

A. Hauschild, P. Steigenberger, O. Montenbruck, U. Hugentobler



Agenda

- CONGO Network Overview
- Selected Studies and Analyses
- Lessons Learned
- Summary and Outlook

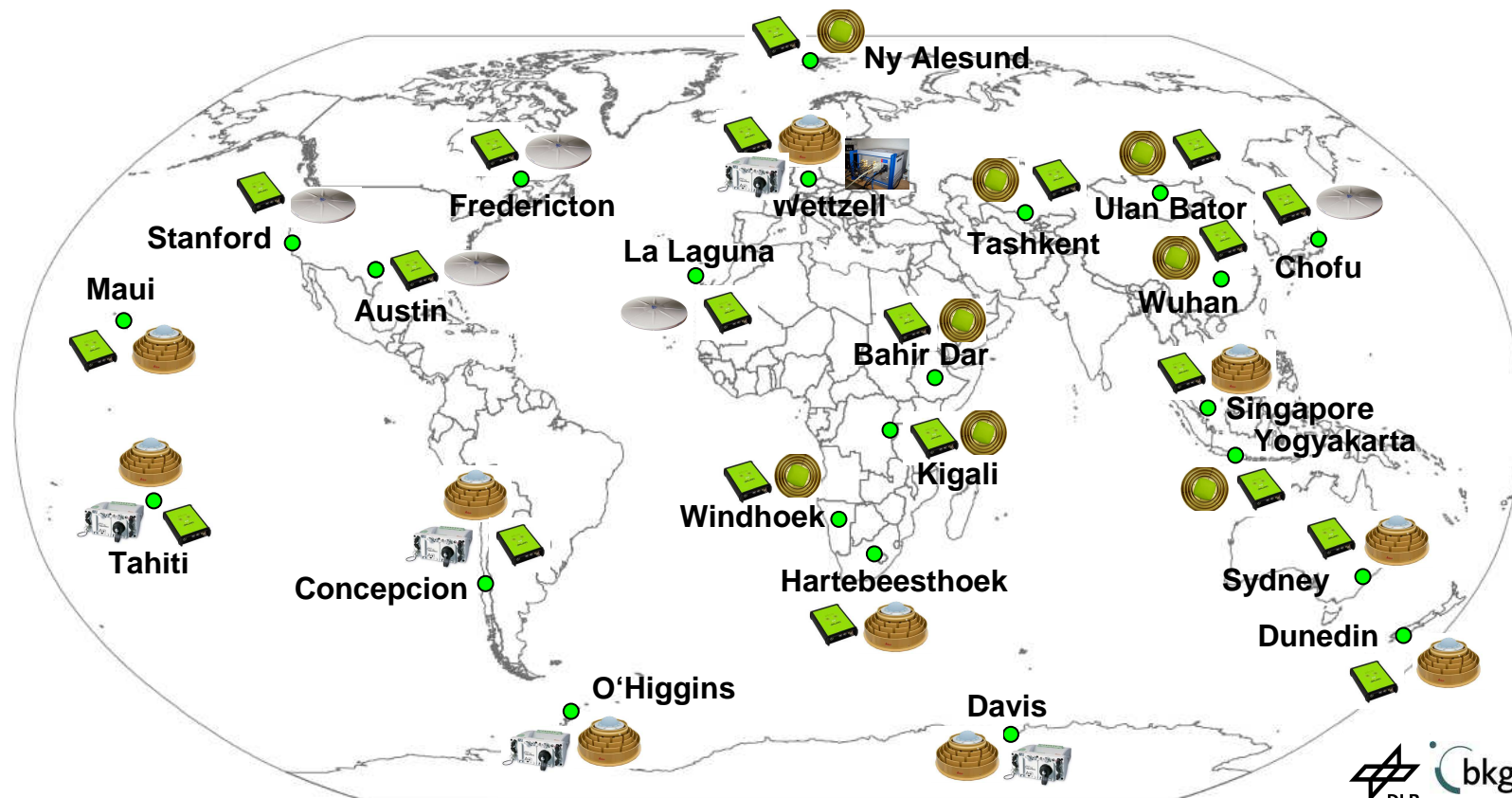


CONGO Network Overview

- Cooperative Network for GNSS Observation (CONGO)
 - formerly the Cooperative Network for GIOVE Observation
- Global network of reference stations with GNSS receivers and antennas
- Motivation:
 - a) Early analysis of new satellite navigation systems
 - b) Preparation of algorithms/processing
- Initially established for GIOVE observations by DLR, BKG, GFZ, GA, CNES
- Supported by many station hosts around the world
- Data and processing center at IAPG/TUM
- CONGO provides observations for GPS (L1,L2,L5), GIOVE / IOV, QZSS, COMPASS, SBAS and GLONASS
- Real-time transfer of observations



CONGO Network Overview





Selected Studies and Analyses

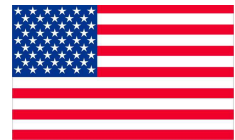


➤ GIOVE / IOV precise orbit and clock determination

Steigenberger P., Hugentobler U., Montenbruck O., Hauschild A.; "Precise Orbit Determination of GIOVE-B Based on the CONGO Network"; *Journal of Geodesy* 85(6), 357-365 (2011). DOI 10.1007/s00190-011-0443-5

➤ GIOVE / IOV real-time clock estimation

Hauschild A., Steigenberger P., Montenbruck O.; Hugentobler U.; "Real-Time GIOVE Orbit- and Clock-Product Generation with RETICLE"; IGS Analysis Workshop, June 28 - July 1 2010, Newcastle (2010)



➤ Block IIF line-bias variations

Montenbruck O., Hugentobler U., Dach R., Steigenberger P., Hauschild A.; "Apparent Clock Variations of the Block IIF-1 (SVN62) GPS Satellite"; *GPS Solutions* 16(3):303 (2012). DOI 10.1007/s10291-011-0232-x

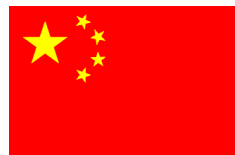


➤ QZS-1 orbit and clock determination

Steigenberger P., Hauschild A., Montenbruck O., Rodriguez-Solano C., Hugentobler U.; "QZS-1 Orbit and Clock Determination"; ION-ITM-2012, 30 Jan -1 Feb 2012, Newport Beach, California (2012).

➤ QZS-1 yaw attitude estimation

Hauschild A., Steigenberger P., Rodriguez-Solano C.; "Signal, Orbit and Attitude Analysis of Japan's first QZSS satellite Michibiki"; *GPS Solutions* 16(1):127-133 (2012). DOI 10.1007/s10291-011-0245-5



➤ BeiDou/COMPASS orbit/clock determination and positioning

Montenbruck O., Hauschild A., Steigenberger P., Hugentobler U., Teunissen P., Nakamura S., "Initial Assessment of the COMPASS/BeiDou-2 Regional Navigation Satellite System"; *GPS Solutions* (2012). DOI 10.1007/s10291-012-0272-x



Lessons Learned I

- Extensive debugging of software, hardware and firmware necessary
 - Time-consuming effort to identify and isolate problems in new features
 - Affects antennas, receivers, auxiliary software (e.g. converters) and analysis software
 - Careful and prompt documentation of ALL configuration changes essential

- Keep raw data files
 - Reconversion of RINEX files possible
 - Helps to recover data after FW changes, detection of converter bugs, etc.

- Extension of data formats for new systems/signals to support ALL observations
 - Proprietary extensions of RINEX v3.00 and RTCM-MSM messages
 - Standardization of formats vs. development status of new systems
 - Lack of information (no ICD available, ...)
 - Sometimes an “educated guess” is necessary!!



Lessons Learned II

- Harmonization of data is necessary
 - Different conventions for spacecraft designations (PRNs for GIOVE, COMPASS)
 - Antenna names (QZSS-SAIF antenna)
- Need for consistent handling of signal biases
 - Inter-system biases, differential-code biases, wide-lane biases, fractional phase-biases are all interdependent
 - Biases may be time-variant or (quasi-) static
- Extension of GNSS attitude models
 - Yaw steering with Sun- or deep-space pointing x-axis
 - Orbit normal mode (QZSS, SBAS, COMPASS GEO)
- We cannot solve unknown problems!!



Summary and Outlook

- CONGO provides early access to new or modernized systems and signals
 - Essential foundation for research
 - Generates helpful feedback to manufactures and system operators

- CONGO and MEGX will most likely face similar challenges → learn similar lessons

- Fundamental problem: defining standards without (reliable) information
 - Should be a case-by-case discussion and decision
 - But should be done as early as possible
 - Avoid “dumping” observations which receivers supply already today