APOS – Austrian Positioning Service on the Way to Multi GNSS

Ernst Zahn, Wien

Abstract

The GNSS GALILEO (EU) und BeiDou (China) are in their final phase to reach their Full Operational Capability (FOC) by 2020. In combination with GPS and GLONASS they will build the so called „Multi GNSS“ for all Positioning, Navigation and Timing (PNT) - applications. The Austrian Federal Office of Metrology and Surveying (BEV) with its GNSS Real Time Service APOS (Austrian Positioning Service) have been adressed this issue since 2016 procuring essential equipment to be ready for the switch to „Multi GNSS“ (GPS, GLONASS, GALILEO) in May 2019.

Keywords: APOS, Multi GNSS, Galileo, FOC, PPP, Troposphere - Correction, Clients

Kurzfassung:

Die GNSS - Systeme GALILEO (EU) und BEIDOU (China) befinden sich in der finalen Phase ihres Vollausbaues (Full Operational Capability – FOC), welcher für das Jahr 2020 geplant ist. Gemeinsam mit den bekannten Systemen GPS (USA) und GLONASS (Russland) wird in absehbarer Zeit ein „Multi GNSS – System“ für sämtliche PNT - Anwendungen (Positioning, Navigation and Timing) zur Verfügung stehen. Das BEV trug mit seinem GNSS-Echtzeitpositionierungsservice APOS (Austrian Positioning Service) diesem Umstand bereits seit geraumer Zeit Rechnung indem 2016 mit den ersten Anschaffungen begonnen wurde und heuer, im May 2019, der Umstieg auf „Multi GNSS“ (GPS, GLONASS, GALILEO) abgeschlossen werden konnte.

Schlüsselwörter: APOS, Multi GNSS, Galileo, FOC, PPP, Troposphärenkorrektur, Kunden

1. GALILEO and BeiDou on the Way to FOC

Parallel to the modernisation of GPS and GLONASS the additional systems GALILEO (EU) and BeiDou (China) are straight on their way to Full Operational Capability (FOC). Up to now GALILEO counts 26 satellites (nominal 24), whereas global 22 satellites are already usable. Additionally a new global operating BeiDou-Generation (BeiDou-III) recently is under construction aiming FOC also by 2020. With the development of a „Multi-GNSS“ basically in terms of increasing stability on signals using more frequency ranges than ever to get better availability etc. new user perspectives can be expected.

2. The Challenging Task to integrate GALILEO into the APOS Services

In GNSS real time positioning APOS and some of its international partners (providers) are using TRIMBLE® – software for their real time network-services, also in combination with 3rd-party receivers. Recently this has caused massive problems due to software bugs and incompatibilities. Roll-outs unfortunately had to be stopped or postponed; scheduled services could not be activated. Meanwhile most problems have been solved. Since begin October 2018 APOS has been ready for processing GALILEO signals. For all clients the service eventually was available at 28th May 2019. Due to the ongoing development of the new generation BeiDou-III and its upcoming implementation possibilities the APOS team decided to extend its services only with GALILEO - corrections in the first run.

3. Multi GNSS on PPP-Basis – A Challenge for Developers and Providers

The future of GNSS-real time services will be determined by the PPP (Precise Point Positioning) -technology. Meanwhile PPP has been implemented in Trimble®'s new „RTX“-Modul as part of the new Trimble® TPP (Trimble Pivot Platform®) processing software and will replace the traditional processing based on base-line differences. This approach requires continuously corrections of satellite-orbits and -clocks of all GNSS as well as operating CORS-receiver code-bias calibrations. For the „APOS Real Time“ service Trimble® provides data and calibration services at a high availability-level.

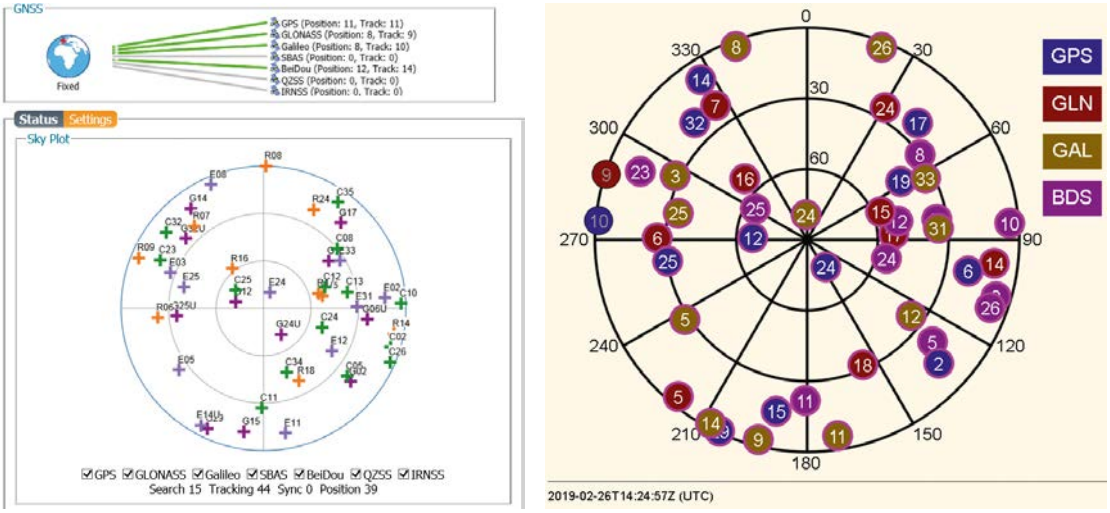

Fig. 1: Sky plots of the multi GNSS - receivers Septentrio® „PolaRX5“ (left) and Trimble® „Alloy“ (right) on 26th Feb. 2019, approx. 14:24 UTC at APOS teststation WIEN

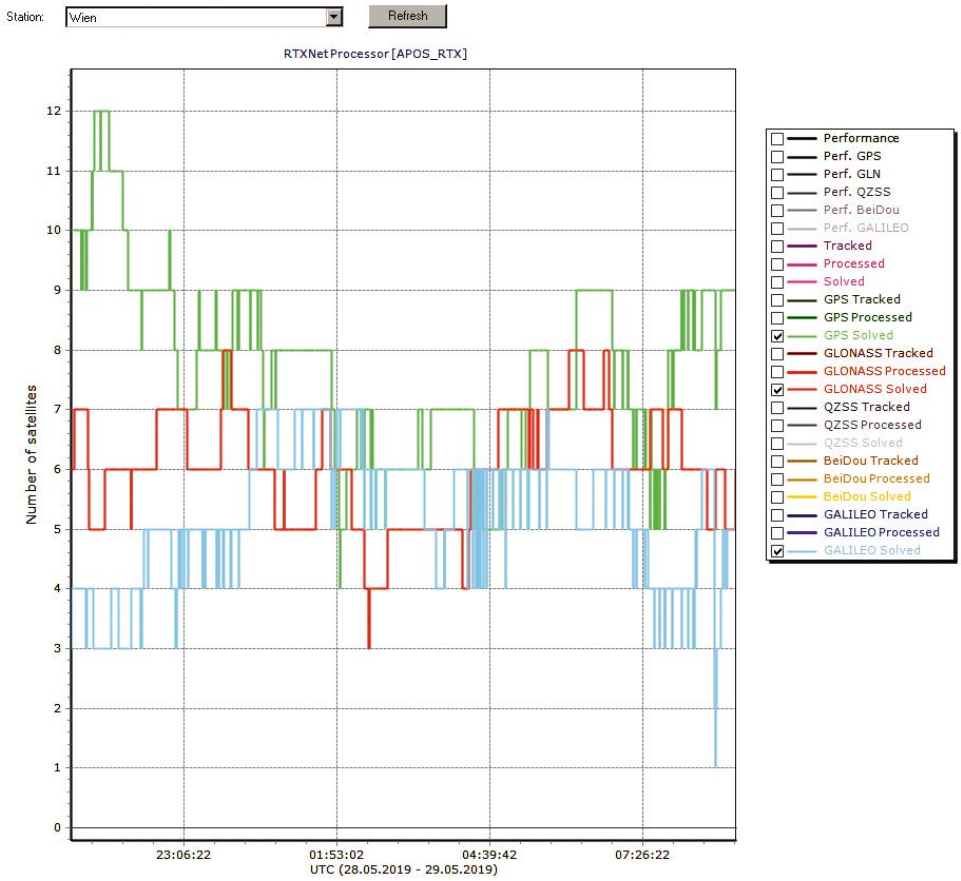

Fig. 2: Trimble® performance plot on 28th/29th Feb. 2019 between approx. 11:00 PM (UTC) and 7:30 AM (UTC) at APOS station Wien/Vienna equipped with Leica GR30

4. The Upgrade of the APOS Real Time Network / APOS Processing Centre

The APOS Real Time Network (Figure 3) actually consists of 65 GNSS-reference stations in Austria and abroad whereas 35 are owned and operated by BEV. All stations have high accuracy ETRS89 (European Terrestrial Reference System)-coordinates and are part of the official ETRS89-realisation in Austria [3]. On a contractual basis between the Leopold Franzens University Innsbruck (LFUI) and the BEV the station Innsbruck was raised and owned by LFUI and is operated by the BEV. Mutual contracts for co-operation between the BEV and all neighbouring national mapping agencies were signed years ago and are essential for the data-exchange across the boundaries between the providers' processing centres. As for the APOS processing centre in 2018 the testing of the Trimble® TPP 3.10.5 processing-software by the APOS team eventually was successful and consequently the roll out of the new multi GNSS-able CORS-receivers, mostly Leica GR30, was completed on schedule. The APOS real time service in general guarantees a homogenous RTK-accuracy in ETRS89 over the whole national territory of Austria.

At the same time a multi GNSS-testbed with Trimble®'s new „RTX"-Modul, based on PPP, has been installed (Figure 4). After the necessary update of the APOS processing center's operating system in December 2018 full redundancy of the „APOS Multi GNSS – production system" has been reached from February 2019.

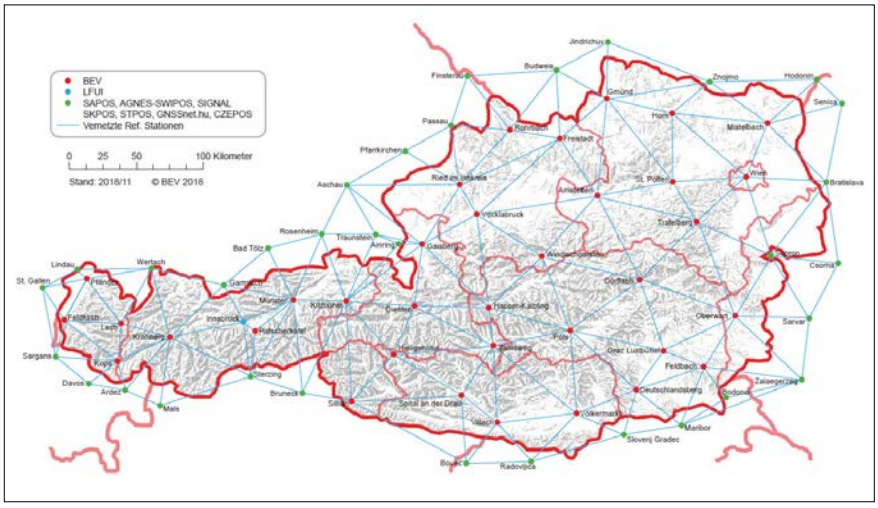

Fig. 3: APOS Real Time Network (Status 2018/11)

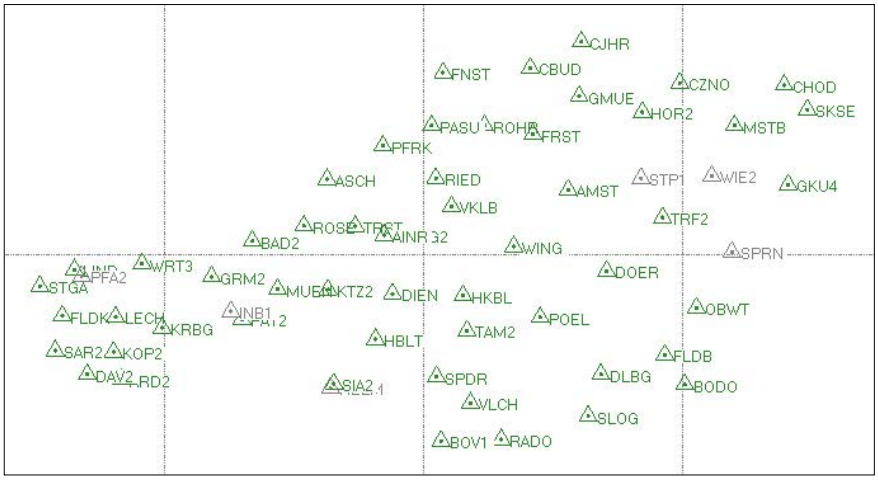

Fig. 4: APOS multi GNSS-testbed covering Austria

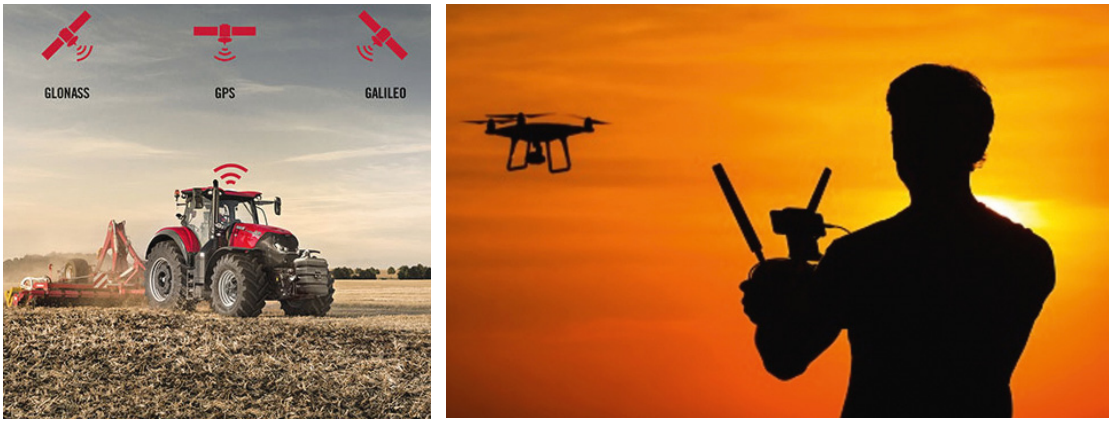

Fig. 5: User-subjects from Case IH (left) and Federal Aviation Administration (FAA) (right)

5. APOS Multi GNSS - Testbed including Troposphere - Correction

The implementation and upcoming release of a multi GNSS-capable system includes the evaluation of nearly countless sensor-configuration possibilities in advance followed up by meaningful testing and analysing, as well as risk estimation of possible problems on clients‘ side. Over the years we became also aware of height accuracy decreases in alpine regions depending on weather situations (e. g. water vapour differences) in conjunction with greater differences in height between local APOS CORS-stations and clients‘ rovers. To avoid that in future Trimble® developed and implemented a special troposphere correction-module for better 3D-interpolation. APOS together with their partners SAPOS-BY and SWIPOS in advance gave support e. g. by routing raw data streams of some of the most relevant alpine APOS CORS-stations (all heights in meter above Adria sea level) for this issue like Innsbruck (615 m, Inn-Valley), the nearby situated Patscherkofel (2249 m, mountain top), Münster (551 m, Inn-Valley) and Krahberg (2208 m, mountain top) to the Trimble®.development division.

As soon as Trimble® released their new module in 2018 the APOS team carried out performance tests using a Trimble® R10 GNSS-rover connected with APOS‘ alternate testmountpoints providing RTCM 3.2 MSM5 (GPS,GLONASS,GALILEO) with and without 3-D interpolation which led to the following questions: firstly, will bring GALILEO‘s recent status a significant additional benefit for e. g. TTFX (time to first fix), availability etc. and secondly, will the 3-D interpolation/troposphere correction module improve height-accuracy. For the latter case the „dual-receiver-CORS-station“ Innsbruck served as a continuous monitoring system, equipped with a Leica AR25.R4 antenna which has been split with two CORS-receivers (Trimble® NetR5 and Trimble® NetR9). The receivers themselves emulated RTK rovers for the alternate dialling into „APOS Real Time“. In both cases the APOS station Patscherkofel served as physical base within the APOS real time network, situated high above Innsbruck-town. Actually an improvement up to 100 % throughout the year was observed despite the fact that the seasonal change of water vapour can infect height accuracy up to several decimetres in alpine regions. Related to that obviously a decrease of accuracy in position has to be taken into account (up to 100 %; for further information see [1]). A remaining activation of the Trimble® troposphere correction-module during testing in eastern parts with lesser alpine character on the other hand showed no bad effects at all.

To summarise the testing the results concerning „Multi GNSS“ with/without GALILEO show no significant differences in performance and accuracy. Measurements were taken in Innsbruck and Wipptal, in the north of Lower Austria and around the Neusiedler See in the eastern part of Austria. In 2018 APOS could not yet reach full „multi GNSS“ (GPS, GLONASS, GALILEO) - coverage because of the APOS partners‘ different GNSS extension (mainly rover-types) levels. So with slight limitations near the national boundaries to South Tyrol and Hungary (Figure 4) the APOS GNSS network is ready for production anyway. To get meaningful results the APOS team and their APOS clients have to look forward to the GALILEO/BeiDou FOC as of 2020 as well as the remaining CORS stations‘ upgrade.

APOS Real Time	Dataformat/ Modus	Mobile Internet Mountpoint (MP)	GPS GLONASS	GALILEO	GIS Grid	Acc. Position		Acc. Height		3D-Interpolation
						ETRS89	MGI	ETRS89	MGI	
APOS - DGPS	RTCM 2.3 (VRS)	APOS-DGPS	✓			± 0,5 m		± 0,5 m		
APOS - RTK	RTCM 2.3 (VRS)	APOS_VRS	✓			± 1,5 cm	< 15,0 cm	± 4,0 cm	< 15,0 cm	
	RTCM 3.1 (VRS)	APOS_VRS3	✓		✓	± 1,5 cm	< 15,0 cm	± 4,0 cm	< 15,0 cm	
	RTCM 3.1 (MAC)	APOS_NET3	✓		✓	± 1,5 cm	< 15,0 cm	± 4,0 cm	< 15,0 cm	
		APOS_VRS32_MSM	✓	✓	✓	± 1,5 cm	< 15,0 cm	± 4,0 cm	< 15,0 cm	
	RTCM 3.2 MSM5 (VRS)	APOS_VRS32_MSM_3D	✓	✓	✓	± 1,5 cm	< 15,0 cm	± 4,0 cm	< 15,0 cm	✓

Tab. 1: APOS Real Time - product portfolio (extract) [2]

6. APOS – Clients and their recent and future Requirements

For a growing number of APOS clients real time GNSS-based height measuring in practise already became more and more important. Applications include e. g. lift operators in skiing areas using snow-height measurement systems mounted on snowgrooming vehicles in combination with GIS-based snow management systems, the construction industry which requires better real time height results for road construction, the agriculture with its special ICT applications as well as the automotive and UAV sector, etc.. The miniaturization of GNSS-devices with its goal to reach centimetre-accuracy is a steady ongoing development process and should be in our focus.

7. APOS – What is coming up next?

In a first step the „APOS Real Time“ service started to provide additionally GALILEO-corrections in May 2019 (Table 1). Further developments comprise the integration of BeiDou III and a renewed multifunctional „BEV Shop APOS“ within the „APOS Postprocessing“ service including e. g. the online provision of RINEX 3 (incl. GALILEO), an online baseline calculation tool, a new user interface for better handling, APOS system's performance information, etc..

8. APOS – Statistics

From the statistic side of view the RINEX availability for all 36 BEV/APOS CORS stations was 99.96 percent (06:00-19:00 CET) resp. 99.99 percent on average (00:00-06:00 / 19:00-24:00 CET) with status November 2018. As of April 2019 APOS serves more than 1150 clients with more than 1900 accounts in all areas of applications, and the number of clients is steadily growing.

References

[1] *Titz H., Freitag M.,* Improving GNSS Realtime Height Measurements in Mountain Areas – Activities of the D-A-CH Group in the Alpine Region, Österreichische Zeitschrift für Vermessung und Geoinformation 107. Jg. 2019, Heft 2, Wien.

[2] http://www.bev.gv.at/

[3] *Titz H., Höggerl N., Imrek E., Stangl G.,* Realisierung und Monitoring von ETRS89 in Österreich, Österreichische Zeitschrift für Vermessung und Geoinformation, 98. Jg. 2010, Heft 2, Wien. 2010.

Contact

Dipl.-Ing. Ernst Zahn, BEV - Federal Office of Metrology and Surveying, Division Surveying, Department Control Survey, Schiffamtsgasse 1-3, 1020 Vienna, Austria.
E-Mail: ernst.zahn@bev.gv.at