Twenty Years of EPN: Network Challenges Ahead

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Q. Baire, J. Legrand, E. Pottiaux, F. Roosbeek

EPN Central Bureau, Royal Observatory of Belgium

EUREF symposium, San Sebastian, Spain
May 25-27, 2016
Outline

How we evolved
• 1996-2016
• New EPN Stations
• EPN Densification
• EPOS

Network Challenges
• Updated EPN Guidelines
• Multi-GNSS
• Real-time Monitoring
• Site Log Submissions
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1996-2016 Tracking Network
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Station Capabilities
Glonass & Galileo Tracking

- **GPS-only** (14%)
- **GPS+GLO** (86%)
- **GPS+GLO+GAL** (29%)

Map showing the distribution of Glonass & Galileo Tracking across Europe.
Analysis Centers

Nr of analysis centers

![Graph showing the number of analysis centers over GPS Week]

- ASI
- BEK
- BKG
- COE
- DEO
- GOP
- IGE
- IGN
- LPT
- MUT
- NKG
- OLG
- OLG
- RGA
- ROB
- SGO
- SUT
- SUT
- UPA
- UPA
- WUT
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New EPN Stations

283 EPN stations

20 new stations:
4 in Spain
4 in Sweden
3 in Italy
2 in France
3 in Serbia
2 in the Netherlands
1 in Latvia
1 in Germany
## Capabilities new stations

New active stations between GPS week No 1844 and 1896 (details):

<table>
<thead>
<tr>
<th>4-char ID</th>
<th>Location</th>
<th>Replacement or New</th>
<th>Sat. Sys. Tracking</th>
<th>R-T</th>
<th>Antenna Calibration</th>
<th>Included Since</th>
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</tr>
</thead>
<tbody>
<tr>
<td>BCLN</td>
<td>Sant Vicenc dels Horts, ESP</td>
<td>new</td>
<td>GPS GLO GAL</td>
<td>RT</td>
<td>Individual (GEO)</td>
<td>02-08-2015</td>
<td>07-02-2012</td>
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<tr>
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<td>Bron, FRA</td>
<td>replaces BRON</td>
<td>GPS GLO GAL BDS SBAS</td>
<td>RT</td>
<td>Type mean</td>
<td>26-07-2015</td>
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</table>
### Capabilities new stations

All new stations are tracking Galileo

**Exceptions:**
- Serbian stations: (SABA, NPAZ) → location
- Swedish station: SUN6 → proposed already in 2013
- Italian stations:
  - MATG → proposed with GAL, but presently tracking problem
  - CAG1 → proposed with GAL (twin station), but not (yet) tracking Galileo

#### New active stations between GPS week No 1844 and 1896 (details):

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EPN Densification

http://epncb.oma.be/_densification/

2337 stations (solution)

700 site logs collected

+ 125 site logs of new stations

+ indiv. ant. calib. (optional)
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EPOS

European Plate Observing System
https://www.epos-ip.org/

European E-infrastructure that is presently constructed.

Builds on what already exists (observation networks, data processing capabilities, ...)
European Plate Observing System - EPOS

Integrated access to data, data products, and facilities from distributed research infrastructures, different disciplines
EPN Principle

OPEN access to RINEX data
EUREF stations
Not ALL stations

EPN CB

RDC
(BKG, OLG)

Site Log submission

Upload Site log

Upload RINEX Data

EPN QC / EPN RINEX data

EPN Network

GNSS Network
EPOS Principle

Link to RINEX Data & QC info

EPOS

OPEN access to RINEX data
2500++ stations

GLASS software

Data Repository

Data Repository

QC / RINEX Data

GNSS Network

GNSS Network

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**Larger GNSS networks**

**Multi-GNSS**

**Real-time**

**Long term stability**

**What we face**

**IGS Station Network**
Need strong management from NC with IC, AC, MGEX, etc help.

**IGS projects/experiments**
Need dedicated networks to be accepted to IGS ntwrk.

**IGS “Ntwk of Ntwks”**
NC/IC need to identify more regional bodies with good active stations to underpin all IGS efforts; SIRGAS, EUREF, AFREF,
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Updates of EPN Guidelines

• March. 2015

Guidelines for EPN Data Centres & EPN Broadcasters
  • New guidelines for the broadcasters

• Oct. 2015

Guidelines for EPN Stations and Operational Centers
  • RINEX 3 (long naming convention) recommended (in addition to RINEX 2) for stations providing more than dual freq. GPS+GLO
    • ftp://igs.org/pub/data/format/rinex303.pdf
    • RINEX 3.01, RINEX 3.02 or later
  • Regional DCs (BKG and OLG) accept RINEX 3 data with long names
    • Data show up in same dir as RINEX 2 data
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RINEX v. and long File Names

![Graph showing the number of stations over years for RINEX 3, RINEX 3.02 or 3.03, and long RINEX filenames.](image)
RINEX 3 @ EPN CB

EPN CB updates:

- MySQL database + major web pages updated for new 9-char station name
- RINEX v2 & v3 metadata checks (equipment & observed satellite systems) vs. site log
- RINEX v2 & v3 data availability monitored
- G-nut/Anubis data quality check software (Vaclavovic and Dousa, 2014) routinely run on all RINEX 2 and 3 data:
  - Used operationally for monitoring tracked satellite constellations and frequencies ➔ tracked frequencies web page
  - Time series presently kept internally for evaluating capability to detect already known (historical) tracking problems.
Tracked Frequencies

http://epncb.oma.be/_networkdata/trackedfrequencies.php
Tracked Frequencies

NETWORK & DATA > TRACKED FREQUENCIES

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Frequency-band</th>
<th>GPS</th>
<th>GLO</th>
<th>GAL</th>
<th>BDS</th>
<th>QZSS</th>
<th>SBAS</th>
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<td>✓</td>
<td>✓</td>
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</table>

Using RINEX 3.02 conventions

Stations responding to the criteria

- Select a station -

Additional tracking information available
- from the University of Bern

Map | Satellite

Long Marker Name: ENTZ00FRA
Marker Number: 10014M002
Location: Entzheim, France
Receiver type: LEICA GR25
Antenna: TRM55971.00
Radome: NONE

<table>
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Google Map data ©2016 Google, INEGI 1000 km
Galileo only in RINEX 2

No RINEX 3:
BORJ, CACE, CEU1, CHIZ, COBA, DRES, HELG, KARL, LROC, NEWL, RANT, SALA, SFER, VIGO, ZARA

RINEX 3.01:
BOGI
Quality Monitoring

RINEX 2
GPS+GLO
Dual frequency obs.
Quality Monitoring

RINEX 2
GPS+GLO
Dual frequency obs.
Quality Monitoring Rx v2 & v3

G-Nut/Anubis (Vaclavovic and Dousa, 2014)
Quality Monitoring

G-Nut/Anubis (Vaclavovic and Dousa, 2014)
Quality Monitoring

Ratio observed/expected observations for MATG

RINEX 2 (GPS+GLO+GAL)

G-Nut/Anubis (Vaclavovic and Dousa, 2014)
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Quick Overview of Network Status

EPN network status web page [http://epncb.oma.be/_networkdata/network_status/](http://epncb.oma.be/_networkdata/network_status/)
Real-time Monitoring

**REAL-TIME DATA STREAMS**

<table>
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<tr>
<th>Mountpoint</th>
<th>ASI (status: 2016-01-22 10:45 UTC)</th>
<th>BKG (status: 2016-01-22 10:45 UTC)</th>
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<td>RTCM 3.1- ergnss-ip.ign.es:2101/ACOR0(1)</td>
<td>RTCM 3.1- ergnss-ip.ign.es:2101/ACOR0(1)</td>
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</tbody>
</table>

EPN stream availability at three regional EPN broadcasters (ASI – Italy, BKG – Germany, ROB – Belgium)

[http://epncb.oma.be/_networkdata/data_access/real_time/status.php](http://epncb.oma.be/_networkdata/data_access/real_time/status.php)
Real-time Monitoring

Upgraded real-time monitoring of all EPN broadcasters (ASI, BKG, ROB):

- Crosschecks of equipment metadata in streams with site log and sourcetable
- Crosschecks of message types and sampling rates in streams with sourcetable and streams from other broadcasters

<table>
<thead>
<tr>
<th>ASI/BKG/ROB</th>
<th>UNTR0 RCVR in sourcetable TPS ODYSSEY_E &lt;-&gt; TPS NET-G3A in site log</th>
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<td>JOZ20 Inconsistent messages</td>
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Outline

How we evolved
• 1996-2016
• New EPN Stations
• EPN Densification
• EPOS

Network Challenges
• Updated EPN Guidelines
• Multi-GNSS
• Real-time Monitoring
• Site Log Submissions
Station meta-data Challenges

• Consistency: Stations contributing to several networks (IGS, EPN, EPOS)

• Station managers with large networks (EPOS, EPN densification)

• Present on-line site log validation and submission tool does not satisfy all needs
Progress

• **Script** (perl) that station managers can run locally to validate site logs
  
  ftp://epncb.oma.be
  pub/software/CheckStationLogs/CheckStationLogs.pl

• **GeodesyML**
  
  • Machine-readable XML format that contains all info in the site log
  • Used to update & validate meta-data at 1 place only
  
  → Exchange using web-services
  
  http://geodesyml.org/

Tests will be performed between IGS - EUREF – EPOS
Conclusion

• The work is not yet done....

• Release of new EPN CB web site
  Sept. 2016
Welcome!

EUREF Permanent GNSS Network

The European Terrestrial Reference System 89 (ETRS89) is used as the standard precise GPS coordinate system throughout Europe. Supported by EuroGeographics and endorsed by the EU, this reference system forms the backbone for all geographic and geodynamic projects on the European territory both on a national as on an international level.

The ETRS89 is maintained by the IAG sub-commission EUREF and it is accessed through the EUREF Permanent GNSS Network (EPN), a science-driven network of continuously operating GPS reference stations with precisely known coordinates in the ETRS89.

All contributions to the EPN are voluntary, with more than 100 European agencies/universities involved, and the reliability of the network is based on redundancy and extensive guidelines guaranteeing the quality of the raw GPS data to the resulting station positions. Next to its key role in the maintenance of the ETRS89, the EPN data are also used for a wide range of scientific applications such as the monitoring of ground deformations, sea level, space weather and numerical weather prediction.

Download EPN flyer.

EPN Central Bureau

Quick Station Links

Last Updated/New Pages

2016-04-14 : Official ITRF2014 coordinates/velocities issued by the IERS added to the individual station coordinates webpage (e.g. ACOR00ESP).

2016-02-02 : New page showing the actual tracking status.

2016-01-29 : Real-time webpage updated.

More ...

Next Meetings


2016-05-30/2016-06-02 : 2016 European Navigation Conference (Helsinki, Finland)

2016-06-05/2016-06-09 : 18th International Symposium on Geodynamics and Earth Tides (Trieste, Italy)
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