EUREF's Infrastructure Galileo Ready

International Association of Geodesy Reference Frame Sub-Commission for Europe

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Seventh Meeting of the
International Committee on Global Navigation Satellite Systems (ICG)
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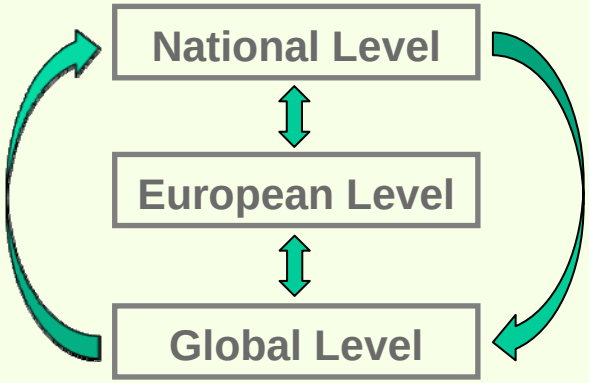
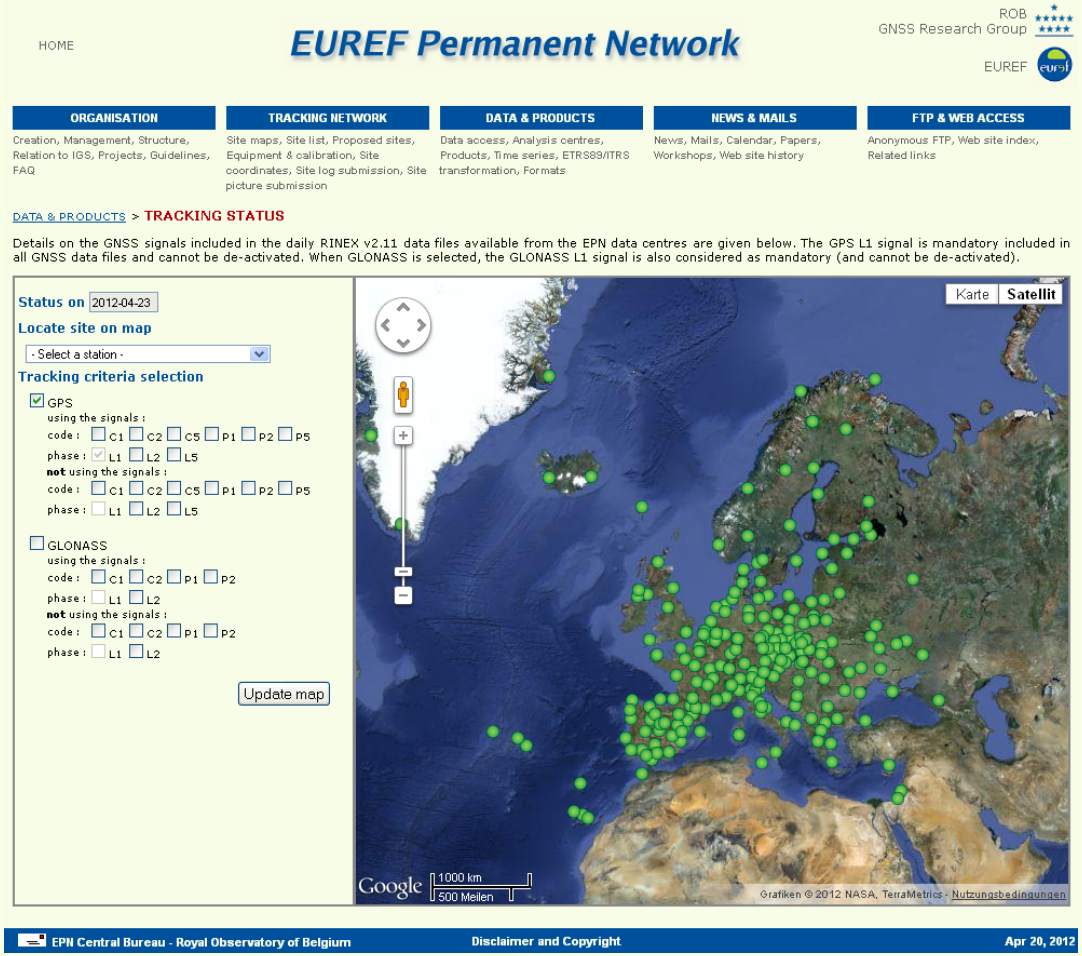
EPN - EUREF Infrastructue

EPN Regional Densification in Europe: Provide reference system data and information in ITRS and ETRS89 to European users by GNSS technologies



GNSS Permanent Network (EPN) with 250 stations

- 130 EPN stations are part of ITRF2008
- About 150 stations provides RT and GLONASS data ⇨ 40 Galileo
- Station movements monitored



Directions of GNSS Satellite Deployment

New navigation satellite constellations and signals, building the "System of Systems"

- Current GNSS satellite constellation
  - 31 GPS operational
  - 24 GLONASS operational
  - 2 Giove and 4 IOV Galileo operational
  - 1 QZSS (tracked by geodetic receiver)
  - 11 COMPASS (tracked by geodetic receiver)
- Frequencies
  - GPS: L1, L2, L5
  - GLONASS: L1, L2
  - Galileo: E1, E5a, E5b, E5
  - QZSS: L1, L2, L5, LEX(6)
  - Compass: E2, E5b, E6
- Tracking Mode (C/A, P, L1C, L2C, I, Q, X=I+Q, …)

Outline -
Evolution of the GNSS Landscape

I. The IGS Multi-GNSS Experiment (M-GEX) and EUREF in practice

II. EUREF's Infrastructure Galileo Ready

III. Reference Frames in Real-Time with PPP-RTK

IV. EUREF: How to proceed?

I. The IGS Multi-GNSS Experiment (M-GEX) - MULTI-GNSS Activities in EUREF

EUREF Symposium 2010 in Gävle recommended:

Resolution no. 3

The IAG Reference Frame Sub-commission for Europe (EUREF)

Noting the leading role that EUREF has taken using and developing the use of GNSS together with the advantages that such leadership has given Science, IAG, EU and NMCAs;

Recognising the GNSS modernisation programmes in particular the European Galileo;

Encourages members of EUREF to provide the necessary infrastructure, data and analysis from these new GNSS developments:

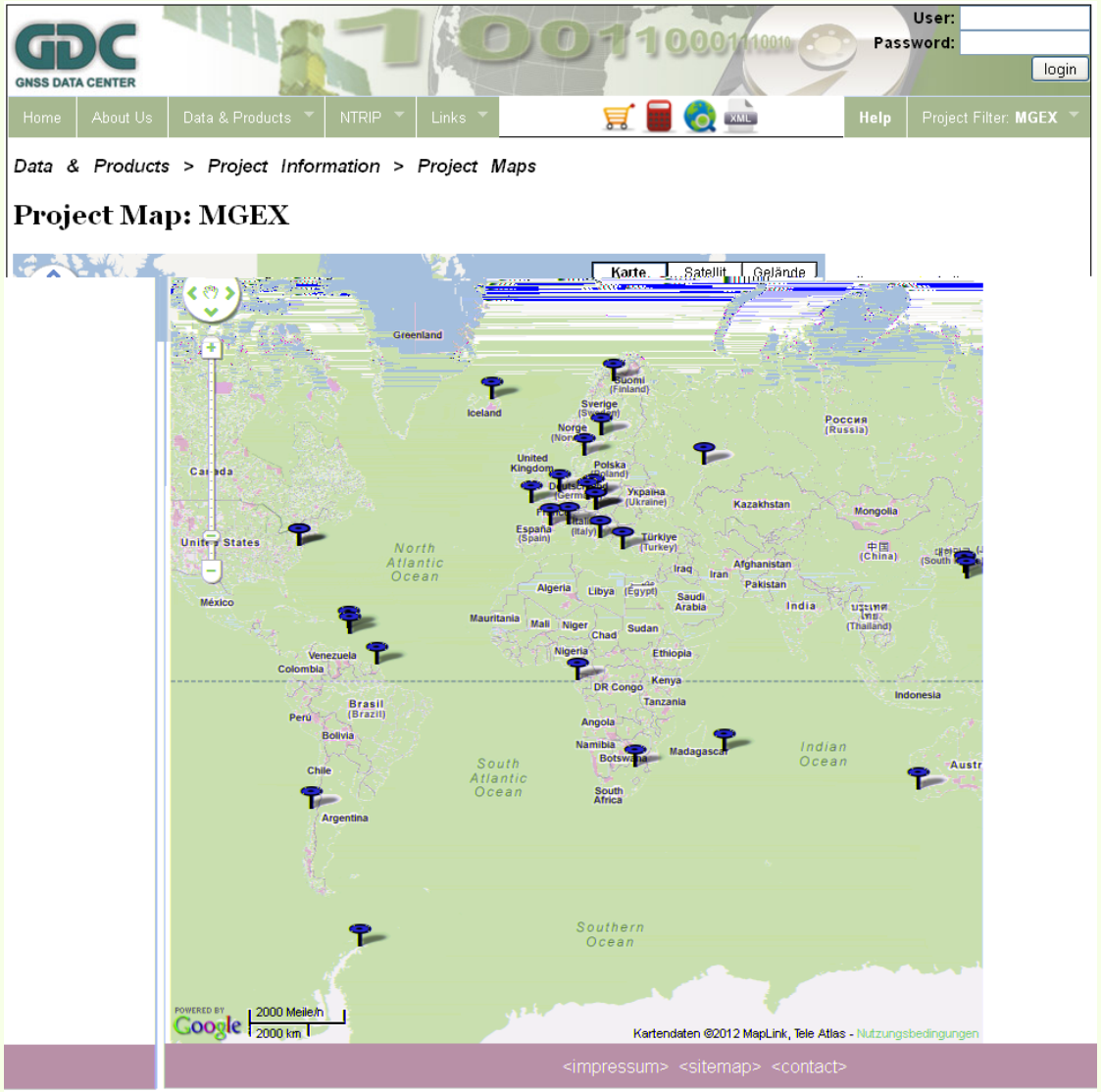
Requests the TWG to establish a platform for the exchange of experiences in upgrading the EPN.

MULTI-GNSS Working Group EUREF

Topics:

- **Handling RINEX3.xx and/or RINEX2.xx and compatibility to RTCM 'High Precision Multiple Signal Messages' (HP MSM) and procedure to implement it to the EPN**
- **Enhancing the EPN infrastructure by Multi-GNSS-ready receivers and antennas**
- **Enhancement method: double stations versus replacing existing analysis of GLONASS data (till now, only the minority of the EUREF analysis centers provide GPS-GLONASS products)**
- **Developing of software (post-processing and real-time) capable to handle multi-GNSS signals.**
- **Define the optimal procedure to have PCV calibrations available which are consistent between the GNSS systems**
- **Setting up a time schedule in order to plan the operational switch to RINEX3 which also is in line with IGS.**

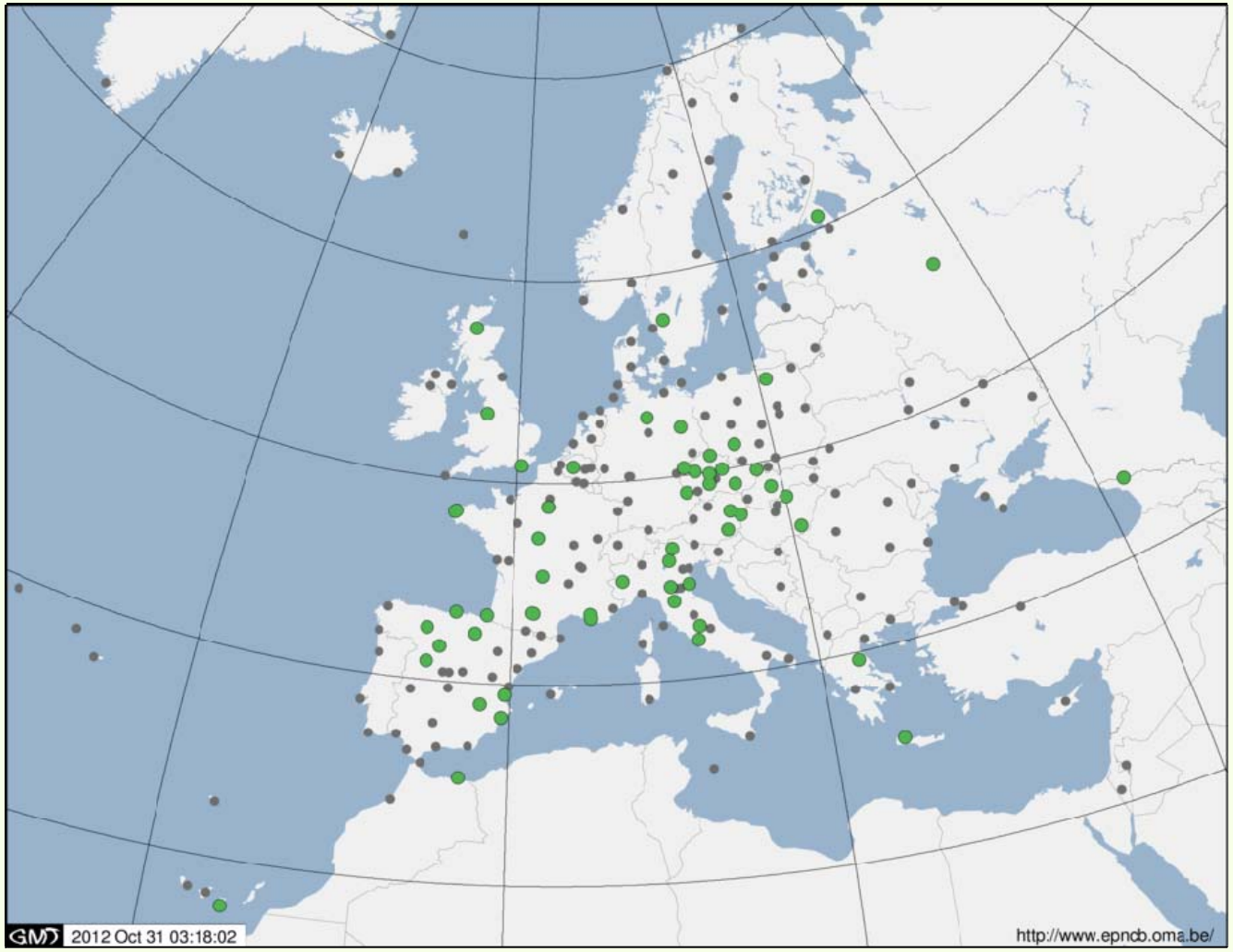
A Data Center for the IGS Multi-GNSS Experiment (M-GEX)



II. EUREF's Infrastructure Galileo Ready

GNSS Permanent Network (EPN) with 250 stations

- About 150 stations provides Real Time and GLONASS data
- ⇨ 40 Galileo stations



Double / Triple Station Concept
Example Zimmerwald (swisstopo, Uni Bern)

Usefull for stations with long time series

MULTI GNSS
(since 2011)

GPS
(since 1991)

GPS + GLONASS
(since 2007)

RINEX3 data availability

- **Status October 2012**
  - **BKG-EUREF: 18 sites (alac alba axpv bbys cant dyng eglt guip ildx m0se rio1 scoa smne tlmf usal vale ven1 vfch)**
  - **BKG-IGS: 26 sites (brst brux conz ganp harb hofn lhaz lmmf mars mat1 mate nklg nurk ous2 pots reun reyk sass tash tlse ulab warn wind wtzr wtzz zim2)**
- **BKG:**
  - **Identical upload directory + automatic recognition which RINEX version is submitted**
  - **Archive under:**
    - **RINEX3: ftp://igs.bkg.bund.de/IGS/obs_v3/yyyy/ddd**
    - **RINEX2.11 ftp://igs.bkg.bund.de/IGS/obs/yyyy/ddd**
- **CDDIS:**
  - **Send RINEX2.11 and RINEX3 files to different upload directories**
  - **Archive under: ftp://cddis.gsfc.nasa.gov/pub/gps/data/rinex3test/daily**

III. Reference Frames in Real-Time with PPP-RTK

Why is EUREF Involved in Real-Time GNSS?

Support research organizations, universities, national mapping and cadastral agencies:

- **GNSS performance monitoring**
- **Providing precise positioning data and information**
- **Rapidly detecting, locating, and characterizing hazardous events such as earthquakes and tsunamis**
- **Geophysical hazard detection and warning systems**
- **Space weather forecasting**

IGS Real-time GNSS Service

- **Real-time IGS Working Group since 2001**
- **Real-time Pilot Project since 2007**
- **Analysis Centers:**
  BKG, CNES, CTU, DLR, ESA, Geo++, GMV, GZF, NRCan, Wuhan
- **IGS permanent RT service announced**

Further RTCM Standardization for PPP

- **Will add messages for global ionosphere and phase biases to allow Ambiguity Resolution**
- **Will add troposphere info to allow PPP-RTK through Regional Augmentations**
- **Approach requires access to a net like EUREF's EPN**
- **Approach requires dense CORS networks from National Mapping Agencies**

Reference Frames in Real-Time

- Local RTK networks
  - better realisation of ETRS89 in all countries
  - long term maintenance of ETRS89 also in tectonically affected areas
  - a few cm accuracy within a few observation epochs
  - local reference stations and reference frames realization
  - no activity from EUREF in this domain
- PPP-RTK
  - PPP is global approach
  - provide and apply precise SSR information
  - concept doesn't request local reference stations
  - global reference frame realization; if needed transformed to regional or local reference frames
- Added value: basic input for science and safety (e.g., tectonic risk assessment)

EUREF Real-Time Data Streams

EUREF Real-Time Product Streams

Message	Contents
1057	GPS orbit corrections to Broadcast Ephemeris
1058	GPS clock corrections to Broadcast Ephemeris
1059	GPS code biases
1060	Combined orbit and clock corrections to GPS Broadcast Ephemeris
1061	GPS User Range Accuracy
1062	High-rate GPS clock corrections to Broadcast Ephemeris
1063	GLONASS orbit corrections to Broadcast Ephemeris
1064	GLONASS clock corrections to Broadcast Ephemeris
1065	GLONASS code biases
1066	Combined orbit and clock corrections to GLONASS Broadcast Ephemeris
1067	GLONASS User Range Accuracy

Caster IP:Port	Mountpoint & Input Streams	Ref. Point	GNSS	Messages	Orbits	Reference System	Analysis Center & SW	Register for access
www.euref-ip.net:2101	EUREF01	APC	GPS	1059, 1060	IGS Ultra Rapid	ETRF2000	KF Combination BNC	Registration
www.euref-ip.net:2101	EUREF02	APC	GPS GLO	1057,1058,1059 1063,1064,1065	CODE Ultra Rapid	ETRF2000	KF Combination BNC	Registration

Helmert Transformation Parameters for Transformation to Regional Systems

Regional System	Tx, Ty, Tz (m)	dTx, dTy, dTz (m/y)	Rx, Ry, Rz (mas)	dRx, dRy, dRz (mas/y)	S (10**-9) dS (10**-9/y)	T0 for Rates
ETRF2000	0.0541 0.0502 -0.0538	-0.0002 0.0001 -0.0018	0.891 5.390 -8.712	0.081 0.490 -0.792	0.40 0.08	2000.0

PPP-RTK & Open Standards

– **Symposium, March 2012 BKG Frankfurt, 190 participants, 34 countries**

– **RT Workshop at the SIRGAS Symposium, Oct. 2012, Concepcion, Chile, 20 countries**

IV. EUREF: How to proceed?
Summary

- **EUREF supports all satellite navigation systems**
  - data archive extended by RINEX version 3
  - GLONASS recommended in analysis guidelines
  - website at EPN central bureau ready for multi-GNSS
- **EUREF established real-time services**
  - data and product streams
  - permanent PPP monitoring
  - development of tools, e.g., BNC
- **EUREF organizations take part in Galileo developments**
  - Galileo reference frame
  - Galileo geodetic working group

EUREF: How to proceed?

- EPN stations shall configured, where possible, with Galileo and GPS L5 signals ready receivers
- Regional and local densification of RT infrastructure testing of real-time precise point positioning (PPP) in the ETRS89 with recent available corrections in the RTCM standard for satellite orbits, clocks and biases
- Help in developing Open Standard for PPP with Ambiguity Resolution and PPP with Regional Augmentation
- Setup/Maintain independent European continental PPP service resources in cooperation with NMAs
- Convince manufacturers to support RTCM SSM messages in receiver firmware

NMAs: How to proceed?

- **Today's Network RTK resources will not become obsolete, PPP-RTK just develops towards an alternative**
- **Pick up EUREF´s PPP product for further dissemination through national Ntrip resources**
- **Test & validate EUREF´s PPP in their countries, Open Source software available through BNC and RTKLIB**
- **Consider making use of EUREF´s real-time product part of the national real-time product portfolio**

EUREF prepare a Multi-GNSS-RT-Service