

IAG/FIG Commission 5/ICG Technical Seminar

Reference Frame in Practice

Rome, Italy 4–5 May 2012



AN EXAMPLE OF TERRESTRIAL REFERENCE FRAME REALISATION: GERMANY

Volker Schwieger

FIG Commission 5: Positioning and Measurement /
University of Stuttgart, Institute of Engineering Geodesy

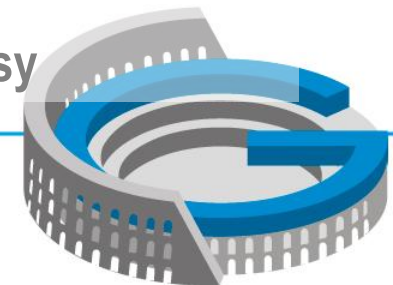
Sponsors:



esri



Trimble



Reference Frame in Practice

Rome, Italy 4–5 May 2012



Structure

- German Specialities
- Definition of Reference Frame
- Realisation of Reference Frame
- GNSS CORS Networks
- GREF
- Control and Maintenance
- Summary

Sponsors:



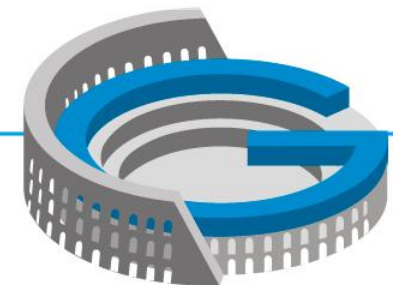
esri



Trimble



CIPAG

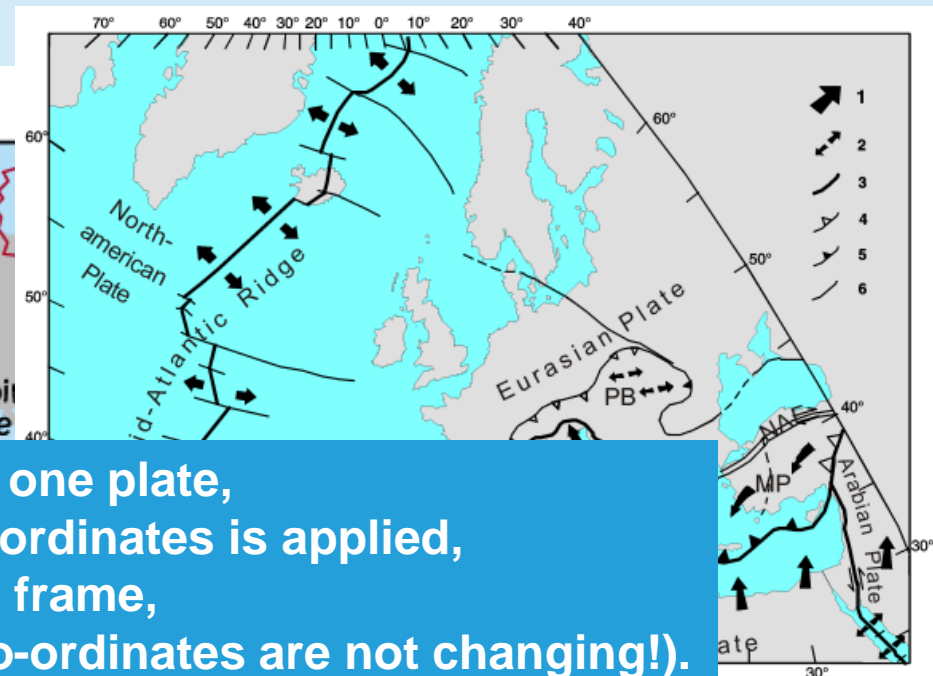
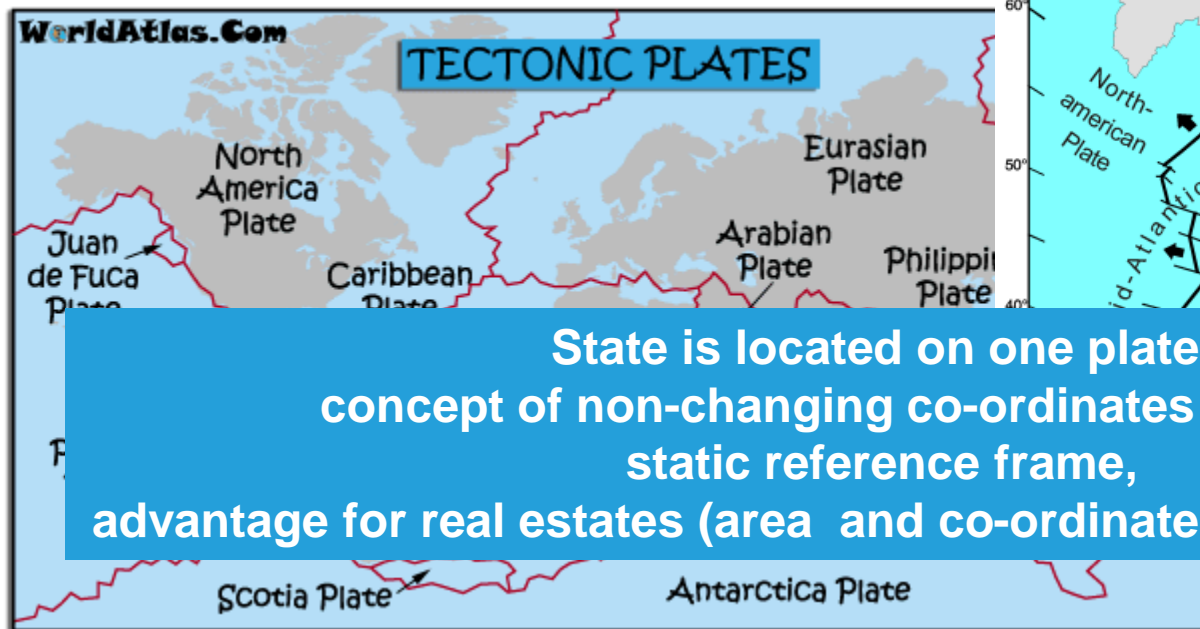


Reference Frame in Practice

Rome, Italy 4-5 May 2012



German Specialities (1)



**State is located on one plate,
concept of non-changing co-ordinates is applied,
static reference frame,
advantage for real estates (area and co-ordinates are not changing!).**

Source: <http://www.gfz-potsdam.de>

Source: <http://eclecticplanet.org>

Sponsors:



esri



Trimble



CIPAG



Reference Frame in Practice

Rome, Italy 4–5 May 2012



German Specialities (2)

- Surveying / Geodesy is under the responsibility of the federal states:
- 16 state surveys with their respective responsibilities
- Bundesamt für Kartographie und Geodäsie (BKG / Federal Agency for Cartography and Geodesy) is responsible for maintaining the German Reference Frame



Sponsors:



esri



Trimble



Source: <http://www.nationsonline.org/>

Reference Frame in Practice

Rome, Italy 4–5 May 2012



Definition of Reference Frame

**May fixed co-ordinates result in problems,
since GNSS orbits are given in respective current IGS realisation?**

**Relative GNSS currently without problems,
absolute solutions (e.g. PPP) have to consider transformations to ETRS89.**

Current Reference Frame

1991: ETRS89 was established as reference system, using GRS80 ellipsoid;
co-ordinates were fixed on values of 01.01.1989 (ETRF89)
(despite of 25 mm per year north-east movement)

1995: UTM was established as mapping projection

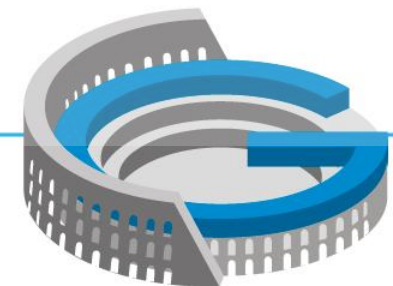
Sponsors:



esri



Trimble



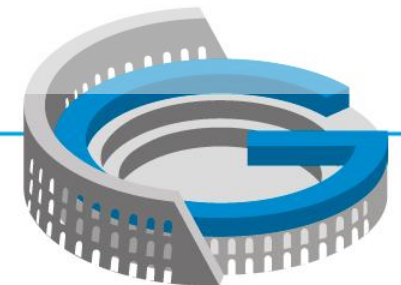
Reference Frame in Practice

Rome, Italy 4–5 May 2012



Realisation of Reference Frame

- DREF91 (German Reference Frame 1991)
- Densification of 15 German ETRF89 / EUREF points (A-network) by 84 new points (B-network)
- Accuracy of 1 – 2 cm horizontal and 2 – 4 cm vertical
- Further densification under the responsibility of the different state surveys (C-network); e.g. in North Rhine Westphalia: 169 points with 15 – 20 km point density
- A-, B- and C-networks are hierarchical adjusted
- Some stresses occur due to the available satellite configuration and measurement technique in these years, especially in the height component



Sponsors:



esri



Trimble



CIPAG

Reference Frame in Practice

Rome, Italy 4–5 May 2012



Realisation of Reference Frame

- SAPOS (Satellitenpositionierungsdienst der deutschen Landesvermessung / Satellite Positioning Service of the German State Survey) is the CORS network of the German federal states
- Positioning is based on one least-square adjustment solution of one week GPS data (epoch 2002.79) for all 260 SAPOS sites including 8 IGS sites
- Stress-free 1-cm accurate network, homogeneous within Germany, tailored to DREF91 solution, discrepancies to neighboring countries
- Coordinate changes up to 4 cm horizontal and 5 cm vertical with respect to DREF
- Since 2003 valid for all federal states

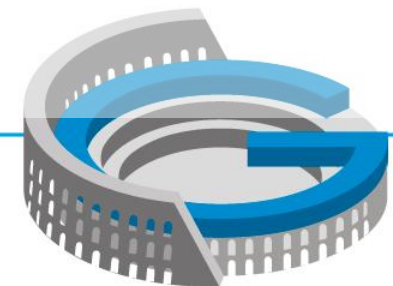
Sponsors:



esri



Trimble



Reference Frame in Practice

Rome, Italy 4–5 May 2012



GNSS CORS Networks in Germany

SAPOS – Official Provider of German Reference Frame

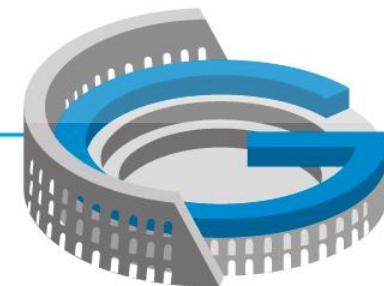
- under the responsibility of 16 state surveys
- service for state and commercial users
- network solutions for all Germany in real time, connection to neighbouring countries

Alternative CORS Networks Services

ASCOS - Allsat and EADS

Trimble VRS Now

SmartNet Germany - Leica



Sponsors:



esri



Trimble



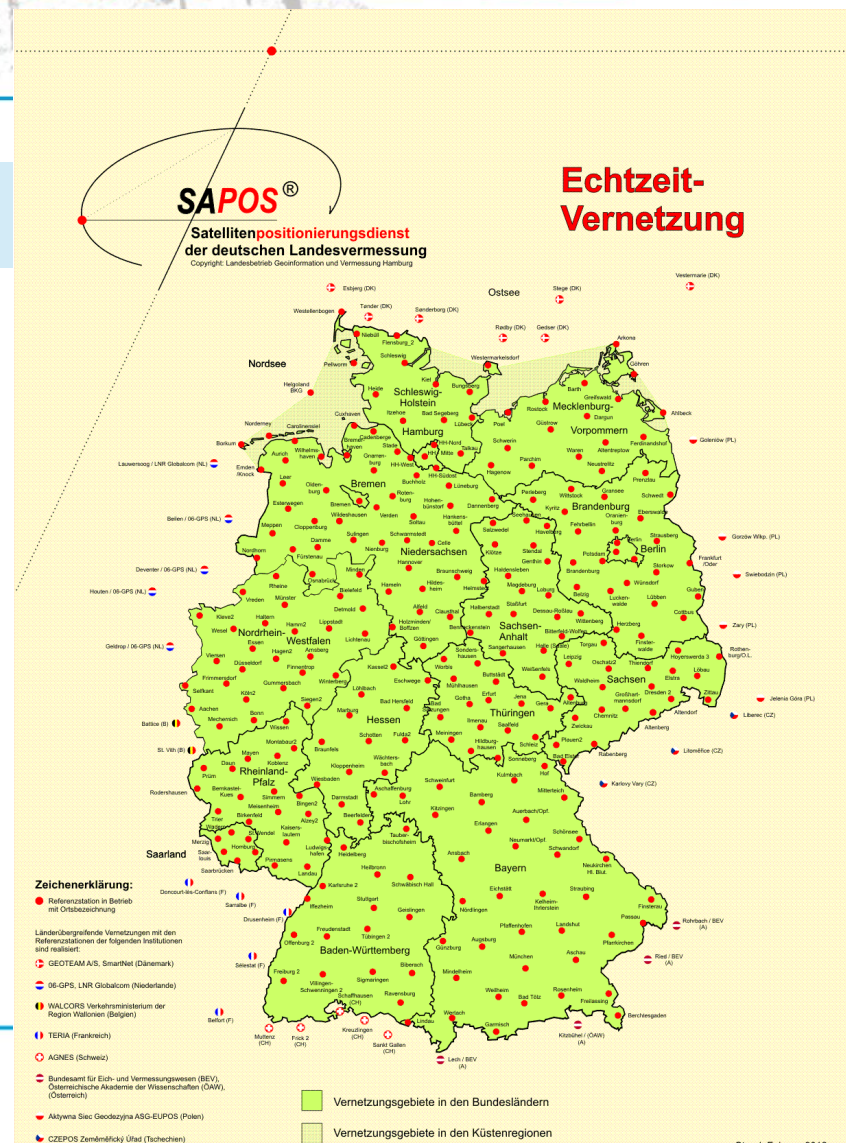
Reference Frame in Practice

Rome, Italy 4–5 May 2012



GNSS CORS Networks in Germany

Real time network solution by SAPOS



Source: SAPOS

Sponsors:



esri



Trimble



Reference Frame in Practice

Rome, Italy 4–5 May 2012



GRAF – Integrated Geodetic Reference Network for Germany

- Around 30 CORS sites, 25 of them are operated by BKG (built up from 2001 to 2007)
- Co-ordinate accuracy: < 0.5 cm horizontal and < 1 cm vertical
- Part of superior networks: EPN and IGS
- Connection to German height and gravity networks as well as gauges
- GPS and Glonass measurements
- Integrated into SAPOS service
- GRAF and SAPOS data is evaluated together regularly by BKG to maintain a homogeneous network for Germany

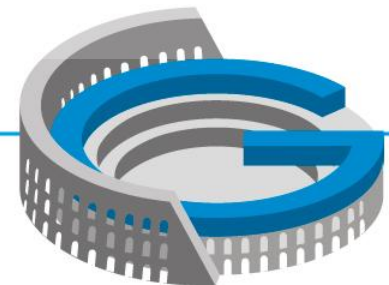
Sponsors:



esri



Trimble

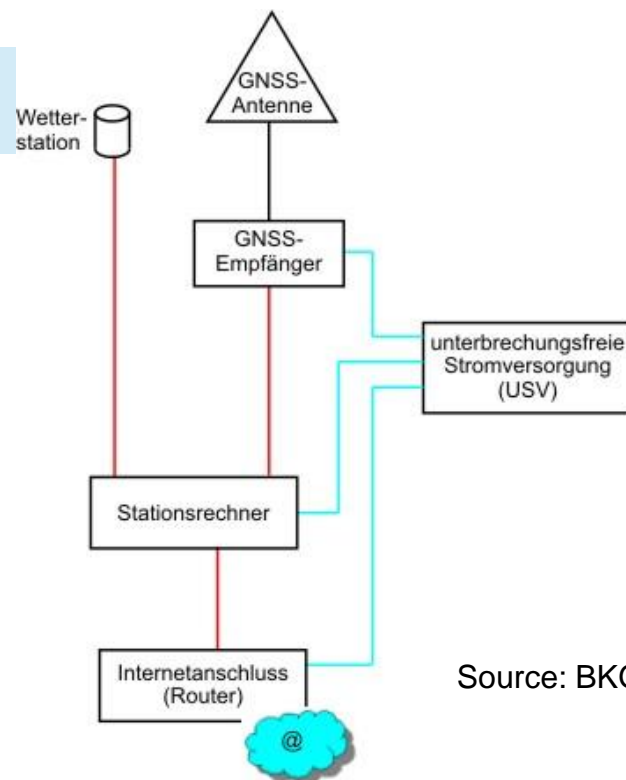
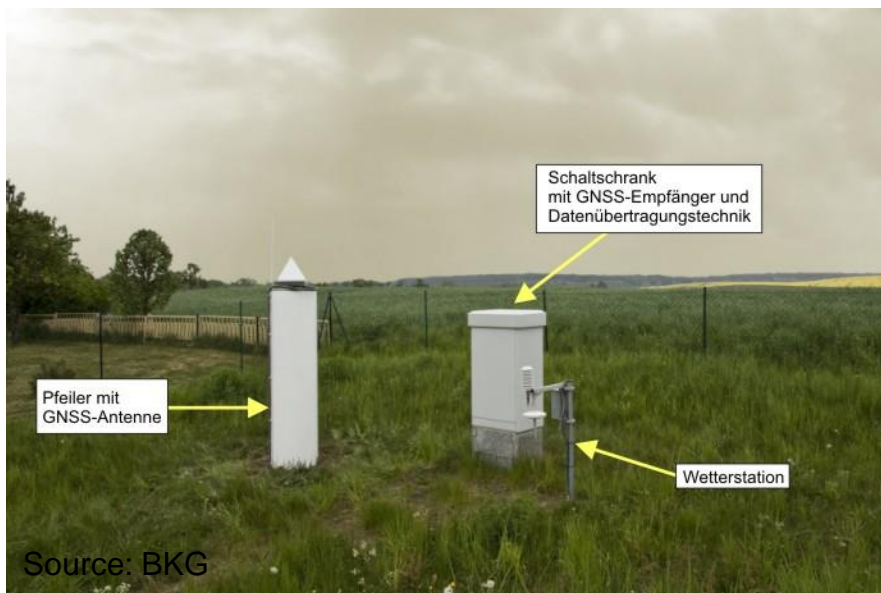


Reference Frame in Practice

Rome, Italy 4–5 May 2012



GRAF



Configuration of a GREF site

Sponsors:



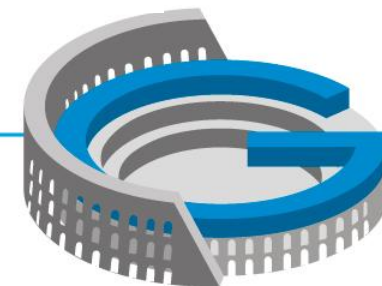
esri



Trimble



CIPAG



Reference Frame in Practice

Rome, Italy 4–5 May 2012



GRAF



Source: BKG

Site on the island Borkum (north see)



Source: BKG

All sites regularly evaluated

Sponsors:



esri



Trimble



CIPAG



Reference Frame in Practice

Rome, Italy 4–5 May 2012

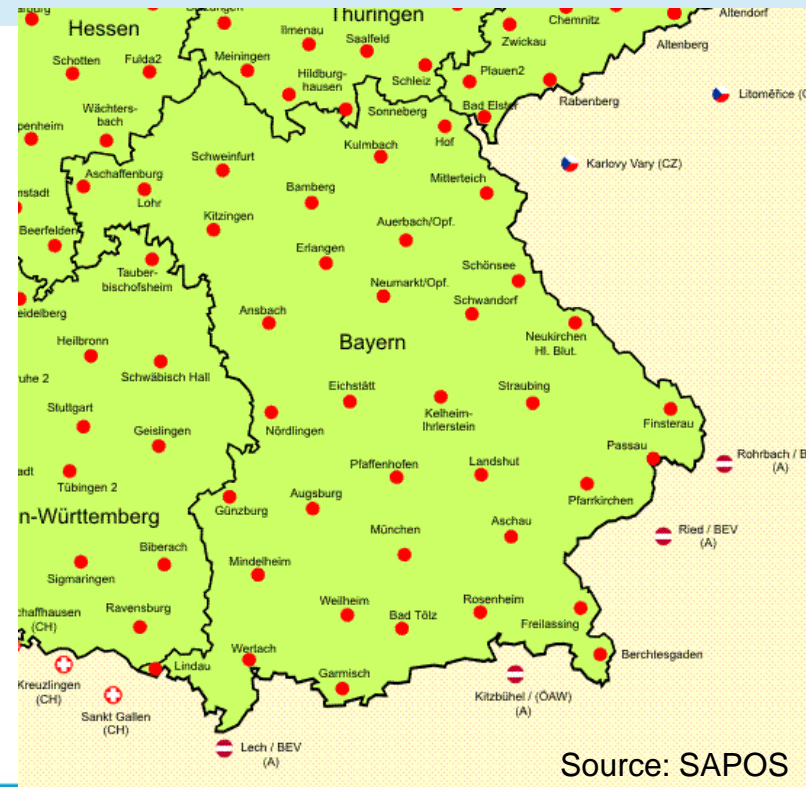


Control and Maintenance

SAPOS Bavaria

has established some tools for monitoring SAPOS and the Reference Frame:
Co-ordinate monitoring,
RTK-peformance,
Network reports.

Other federal state surveys have developed or are developping similar services.



Source: SAPOS

Sponsors:



esri



Trimble





Control and Maintenance

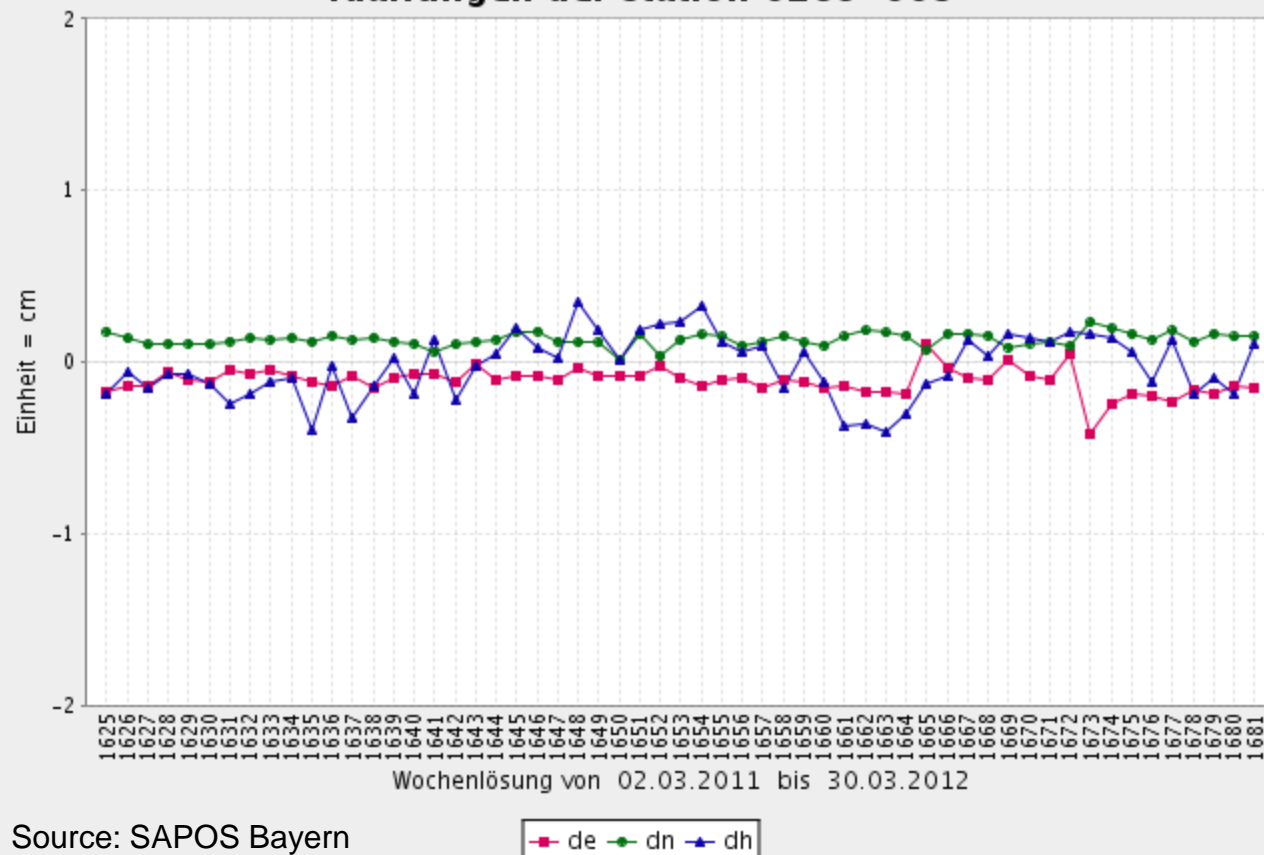
Co-ordinate Monitoring

All reference site co-ordinates are automatically determined using the Bernese software in a multi-site-solution.

The results are published in the web.

Example: site 0269 / Wertach

Klaffungen der Station 0269-003



Sponsors:



Source: SAPOS Bayern



Control and Maintenance

RTK Performance Monitoring

Currently 3 RTK sites that show large distance to other SAPOS sites are performing continuously positioning within the RTK service (40 fixes per hour). The results are summarized in a hourly RTK - Performance Index and published in the web.

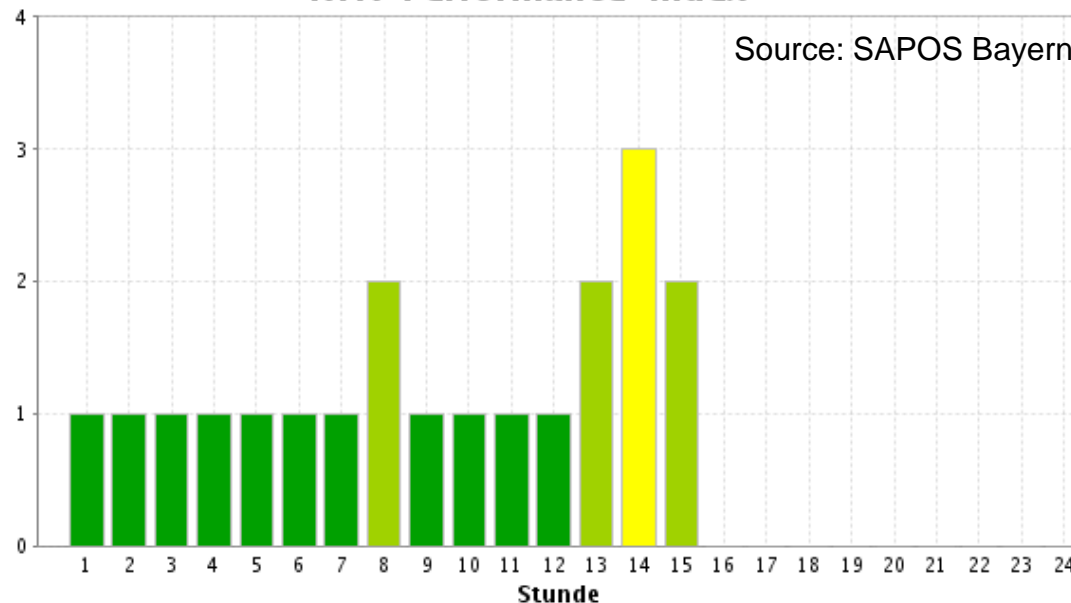
orange / yellow / light green / green:

Hz: 33% > 3 cm / 67% > 3 cm / 90% > 3 cm / 90% > 2 cm

Vt: 33% > 5 cm / 67% > 5 cm / 90% > 5 cm / 90% > 3 cm

TtF: 33% > 3 min / 67 % > 3 min / 90% > 3 min / 90% > 1 min

RTK-Performance-Index



Sponsors:



esri



Trimble



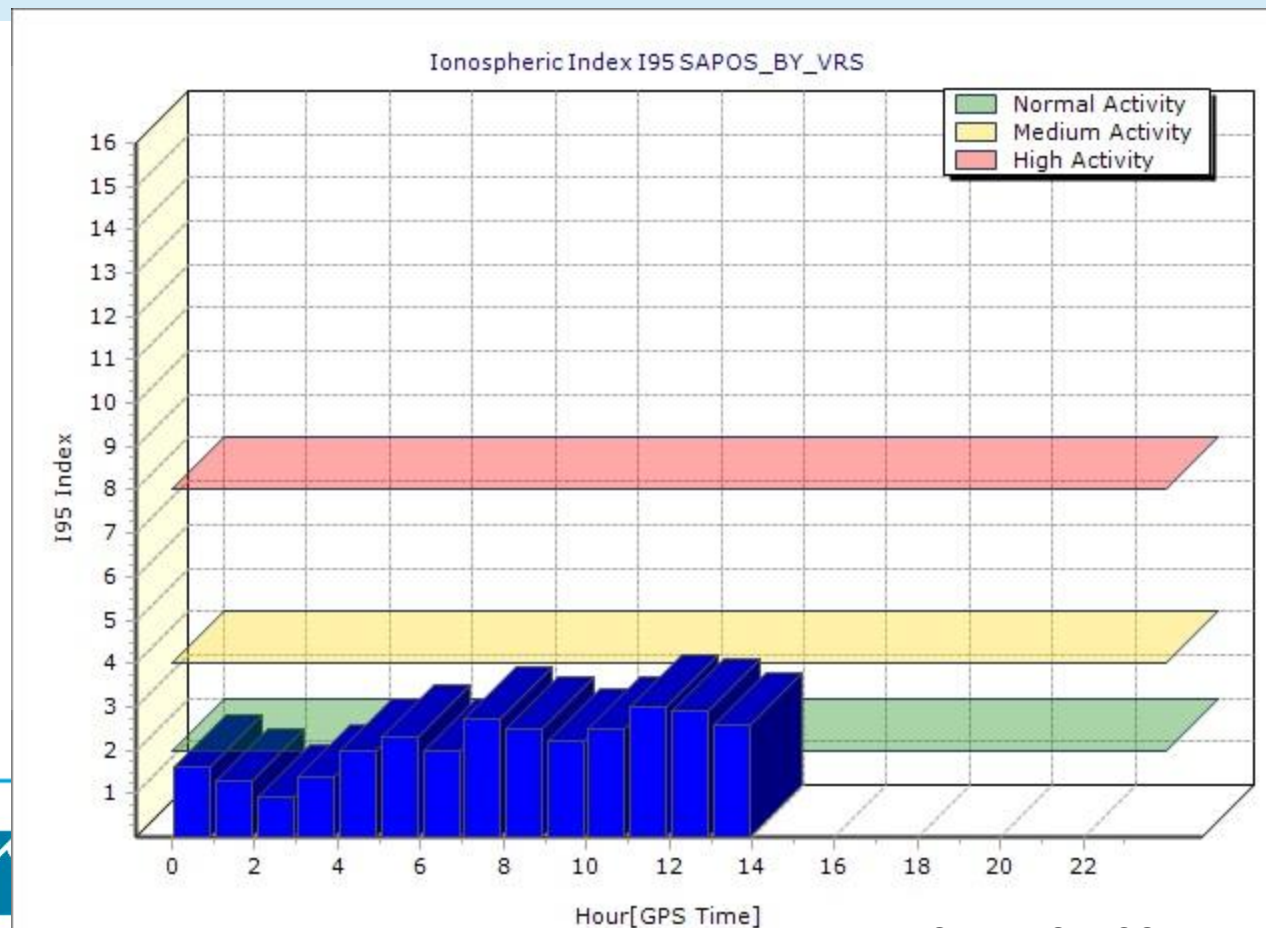


Control and Maintenance

Network Reports

Core element of SAPOS is the network solution that reduces the distance dependent errors of GNSS.

Network report summarize in hourly solutions ionospheric information, as well as predicted remaining errors.



Sponsors:

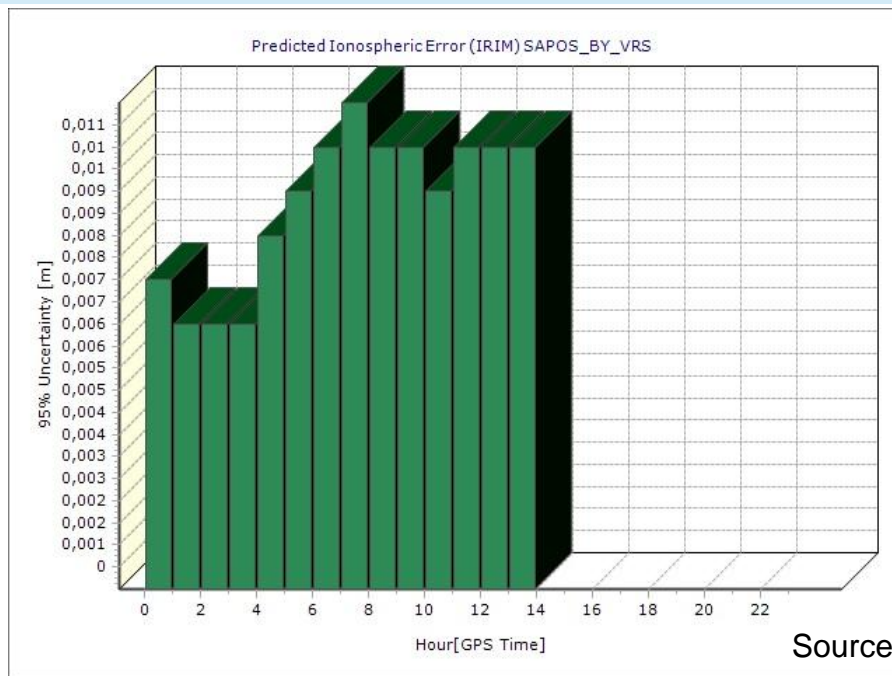


Reference Frame in Practice

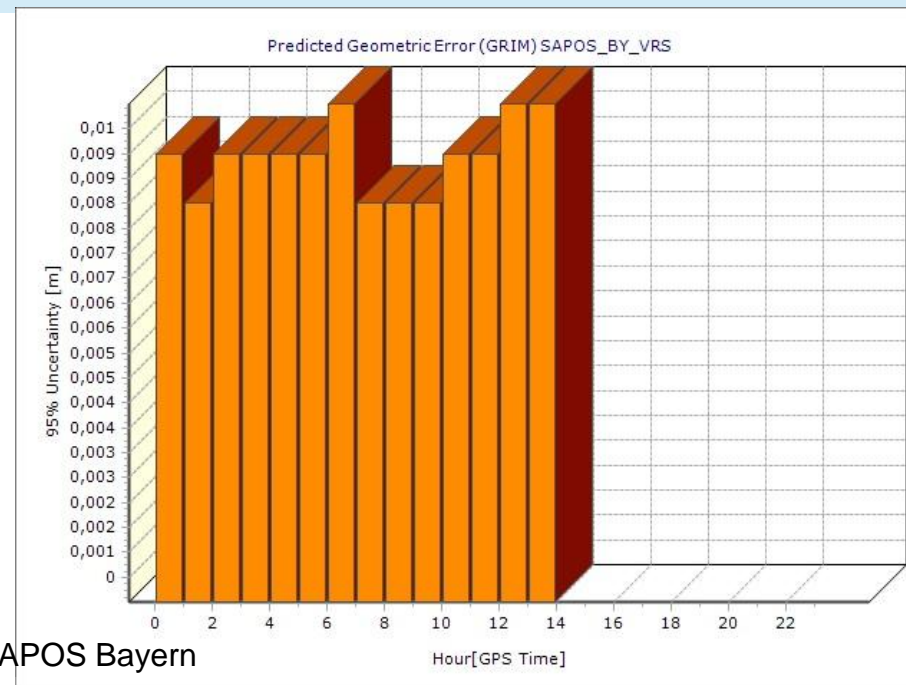
Rome, Italy 4–5 May 2012



Control and Maintenance



Source: SAPOS Bayern



Predicted non-linear errors of ionosphere and other influences

Sponsors:



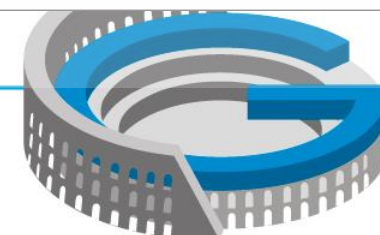
esri



Trimble



CIPAG



Reference Frame in Practice

Rome, Italy 4–5 May 2012



Summary

- Long history regarding reference frames
- Since the nineties: ITRF / ETRF89 based reference frame
- Static reference frame, since no relative movements occur
- Realisation nowadays by CORS network SAPOS
- GREF integrates German 3D reference frame into superior systems as well as national height and gravity networks
- Co-ordinates are controlled regularly on national and federate state level
- Real time control of solutions is transparently realised

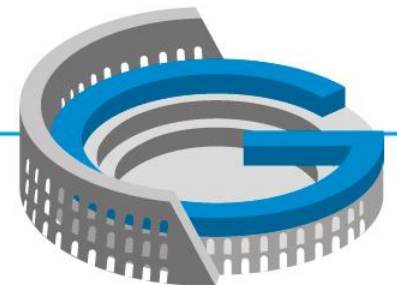
Sponsors:



esri



Trimble



Reference Frame in Practice

Rome, Italy 4–5 May 2012



References

- B. Görres (2010): Vom globalen Bezugssystem bis zur Umsetzung in der Praxis. In: GNSS 2010 - Vermessung und Navigation im 21. Jahrhundert, DVW-Schriftenreihe Bd.63, S. 39-57, Wißner-Verlag Augsburg.
- B. Görres, M. Meyer, A. Nothnagel, B. Heck (2012): DVW-Merkblatt zu GNSS Bezugssystemen (in discussion).
- www.sapos.de
- <http://www.zentrale-stelle-sapos.de/>
- <https://sapos.bayern.de/>
- www.bkg.bund.de

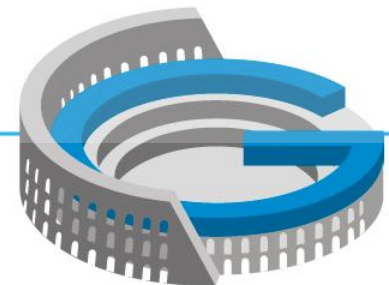
Sponsors:



esri



Trimble



IAG/FIG Commission 5/ICG Technical Seminar

Reference Frame in Practice

Rome, Italy 4–5 May 2012



**Thank you very much for your attention !
Feel free to address your questions !**

Volker Schwieger

volker.schwieger@ingeo.uni-stuttgart.de

FIG Commission 5: Positioning and Measurement /
University of Stuttgart, Institute of Engineering Geodesy

Sponsors:



esri



Trimble

