Cost-Effective GNSS – FIG activities and IIGS Research

(Overview Contribution)

Workshop on Cost Effective Positioning and Geo Data

Volker Schwieger

Institute of Engineering Geodesy (IIGS), University of Stuttgart, Germany

20th April 2017, Novosibirsk, Russia

Overview

FIG Activities

- Commission 5 Mission and Structure
- Publications
- Recent and Future Activities

IIGS Research

- Publications
- History
- Current Results
- Future Plans

International Federation of Surveyors
Fédération Internationale des Géomètres
International Vereinigung der Vermessungsingenieure

Members

- 121 countries represented in 2015 – more than 300,000

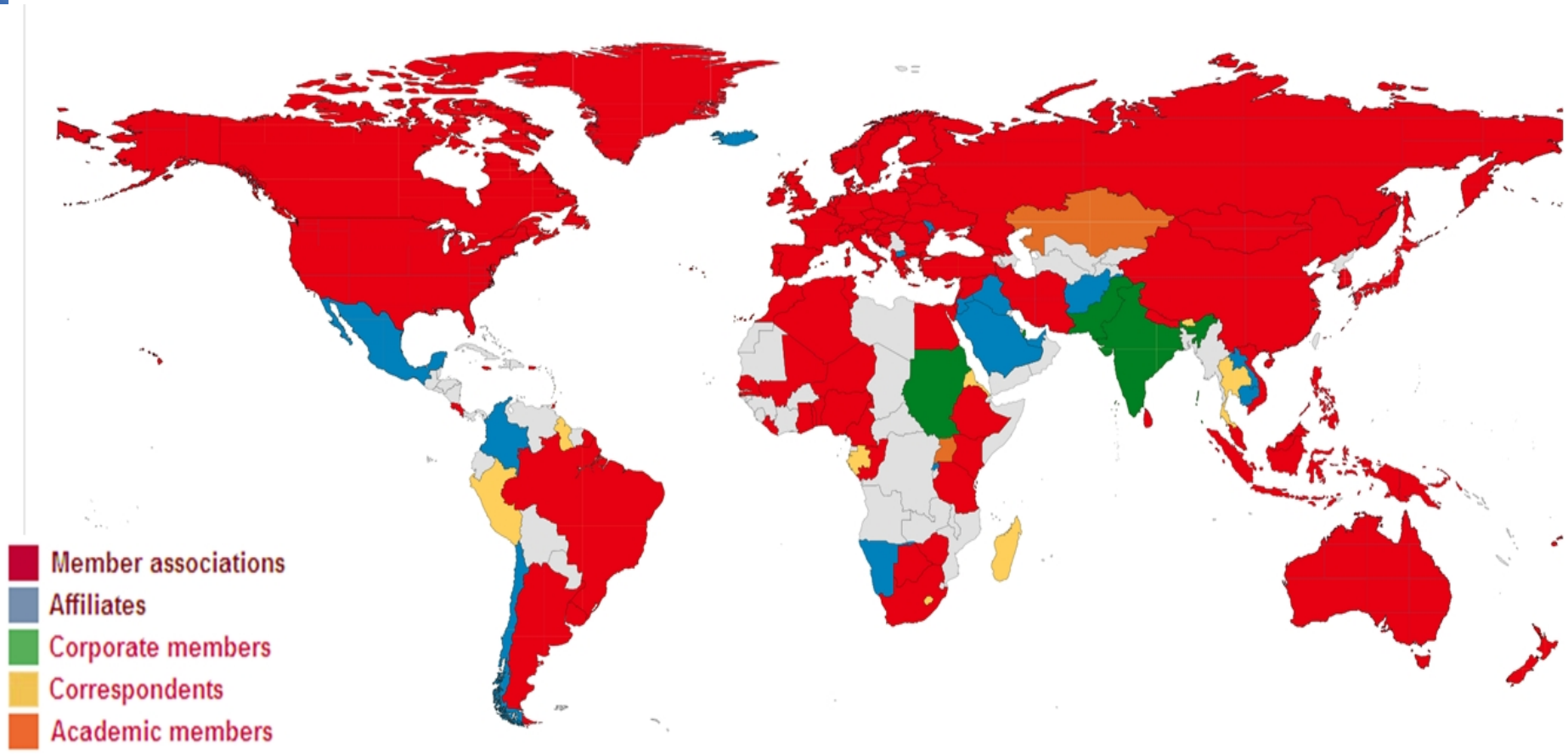


FIG Structure

- Com 1: Professional Standards and Practice
- Com 2: Professional Education
- Com 3: Spatial Information Management
- Com 4: Hydrography
- **Com 5: Positioning and Measurement**
- Com 6: Engineering Surveys
- Com 7: Cadastre and Land Management
- Com 8: Spatial Planning and Development
- Com 9: Valuation and the Management of Real Estate
- Com 10: Construction Economics and Management

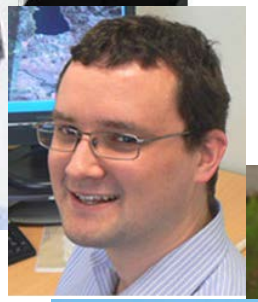
FIG Commission 5 Mission

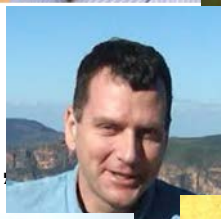
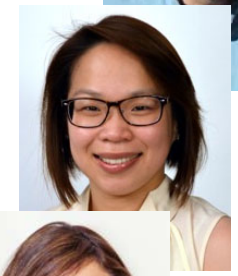
Mission statement - The five ”F”;

- **F**ocus on modern technologies, technical development and assist surveyors through guidelines and recommendations
- **F**acilitate and follow technical development through collaboration with other commissions and other international organisations
- **F**oster and support research and development and stimulate new ideas.
- **F**ormulate and formalise collaboration with manufacturers on the improvement on instruments and associated software
- **F**IG Events – use these to present and promote the work of the Commission and its working groups

FIG Commission 5 Structure




Chair: *Volker Schwieger*, Germany

Vice-Chair of Administration: *Li Zhang*, Germany

WG 5.1: Standards, Quality Assurance and Calibration
(David Martin, France)

WG 5.2: 3D Reference Frames (Nic Donnelly, New Zealand)

WG 5.3: Vertical Reference Frames (Kevin Kelly, USA / Dan Roman)

WG 5.4: GNSS (Neil D Weston, USA / Suelynn Choy, Australia)

WG 5.5: Multi-Sensor-Systems (Allison Kealy, Australia /
Guenther Retscher, Austria / Joint with IAG /Com. 6)

WG 5.6: Cost Effective Positioning (Leonid A. Lipatnikov, Russia)

Relevant FIG Commission 5 Publications

2010 and 2014

Working Group 5.4 GNSS,
Neil Weston & Volker Schwieger

Relevant FIG Commission 5 Publications

Topics

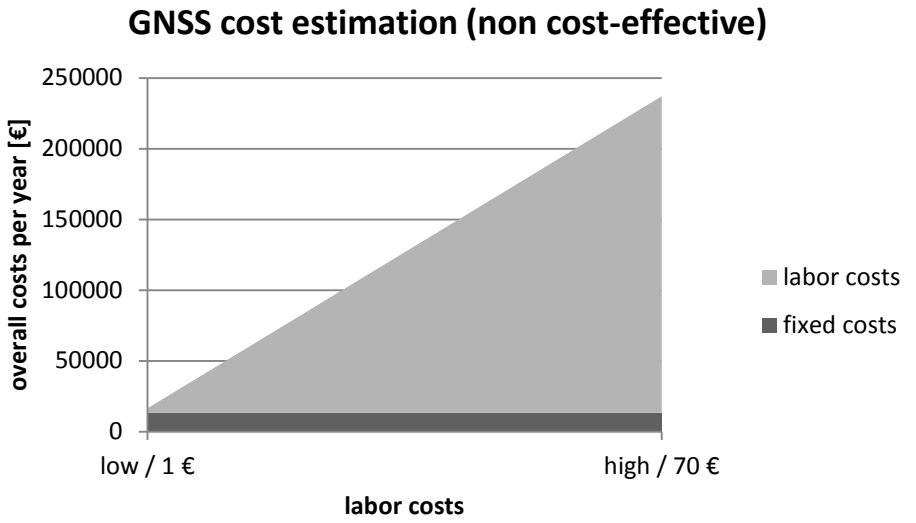
a) Cost-Effective Rovers / Low-Cost GNSS Receivers

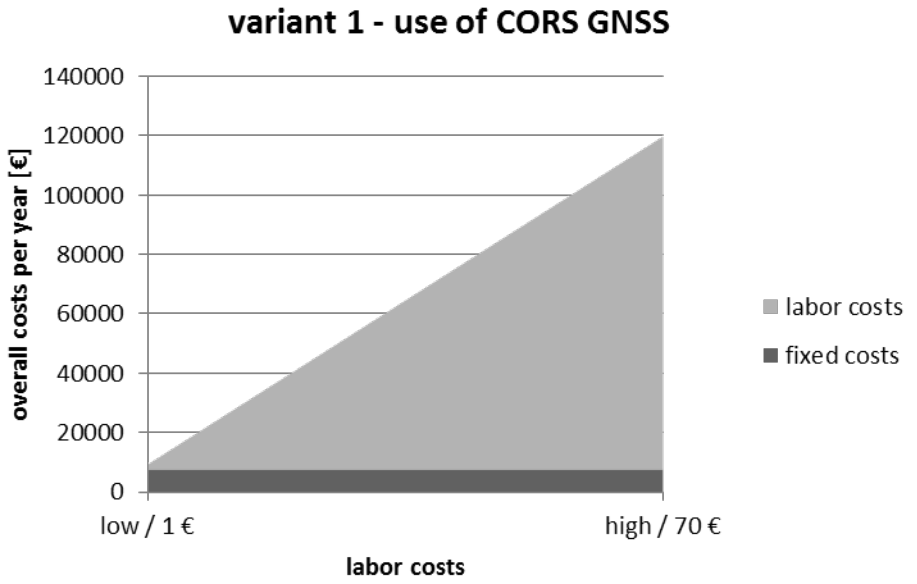
receiver class	used signal	applications	accuracy	costs
navigation	code or phase-smoothed code, 1 frequency	car navigation, location based services, sailing, mass market	1 to 10 m	5 – 100 €
geodetic	code and phase, in general 2 frequencies	surveying, geodesy, geodynamics	0.001 to 0.1 m	10 000 € - 30 000 €

b) Continuously Operating Reference Station (CORS) Networks

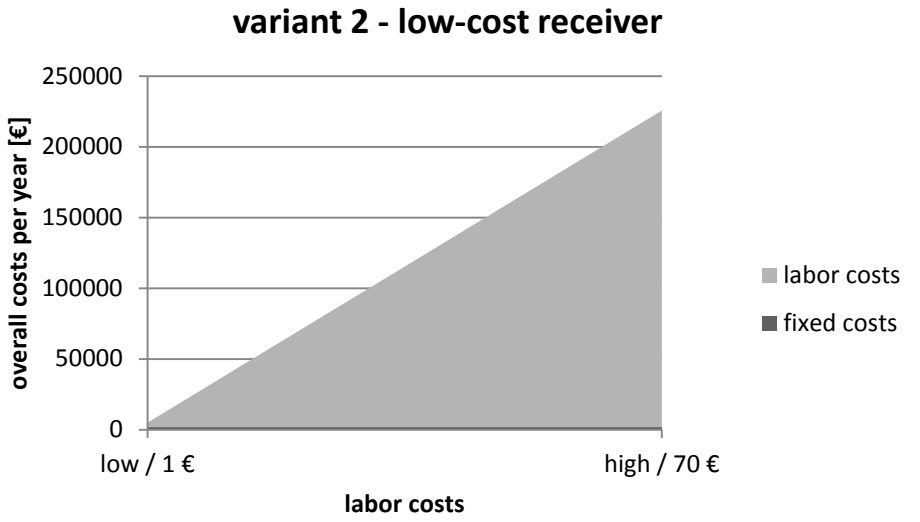
c) Web-based Positioning Tools

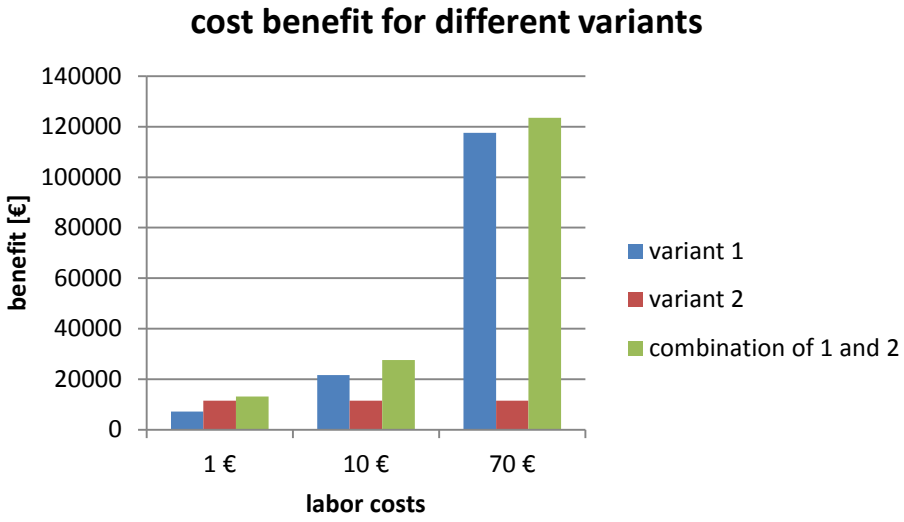
Relevant FIG Commission 5 Publications





Relevant FIG Commission 5 Publications





Recent and Future Activities

Technical Seminar on Reference Frames in Practice

Reference Frames, Datum Unification and Kinematics

1-2 May 2016 at Rydges Latimer, Christchurch, New Zealand

Technical Content

Key topics covered were:

- Introduction to 3D Reference Frames
- Introduction to Vertical Reference Frames
- Kinematic Frames and Deformation Modelling
- International Geodesy Initiatives
  - APREF and UN-GGIM
  - Geodetic Initiatives at ISO
- Geodetic Infrastructure
  - Template for Developing a National Reference Frame
  - International GNSS Service
  - Multi-GNSS
- Geodetic Software
  - SINEX Manipulation
  - RTKLIB
  - SNAP
- Case Studies
  - Australia
  - Fiji
  - Japan
  - Nepal
  - New Zealand
  - Philippines
  - Poland
  - USA

Recent and Future Activities

Technical Seminar on Reference Frames in Practice

Reference Frames, Datum Unification and Kinematics

1-2 May 2016 at Rydges Latimer, Christchurch, New Zealand

Recent and Future Activities

Currently working on New Edition…
Low Cost Precise Positioning,
WG 5.4 and WG 5.6 !

IIGS Research – Publications I

Schwieger, V.: Using Handheld GPS receivers for precise positioning. Proceedings on 2nd FIG regional conference, Marrakesh, Marocco, 2.-5.12. 2003.

Schwieger, V, Gläser, A.: Possibilities of Low Cost GPS Technology for Precise Geodetic Applications. Proceedings on FIG Working Week 2005, Kairo, Ägypten, 16.-21.04. 2005.

Schwieger, V.: Quality of Low-Cost GPS for Geodetic and Navigation Applications. GIS@development Middle East, Heft Nr. 5, September - Oktober, 2005.

Schwieger, V., Wanninger, L.: Potential von GPS Navigationsempfängern. In: GPS und Galileo. Beiträge zum 66. DVW-Seminar am 21. und 22. Februar 2006 in Darmstadt, Wißner Verlag, Augsburg, 2006.

Schwieger, V.: High-Sensitivity GNSS – the Low-Cost Future of GPS ?. Proceedings on FIG Working Week 2007, Hongkong SAR, 13.-17.05. 2007.

Schwieger, V.: High-Sensitivity GPS - an availability, reliability and accuracy test. Proceedings on FIG Working Week, Stockholm, Schweden, 14.-19.06.2008.

Schwieger, V.: Accurate High-Sensitivity GPS for Short Baselines. FIG Working Week, Eilat, Israel, 03.-08.05.2009.

Schwieger, V.: High-Sensitivity GPS für geodätische Anwendungen. 83.DVW-Seminar, GNSS 2009: Systeme, Dienste, Anwendungen. Dresden, 18.-19.03.2009.

Zhang, L., Stange, M., Schwieger, V.: Reducing the Costs of Geodetic Monitoring. GIM International, September 2012.

Zhang, L., Stange, M., Schwieger, V.: Automatic Low-cost GPS Monitoring System using WLAN Communication. FIG Working Week, Rome, Italy, 06.-10.05.2012.

IIGS Research – Publications II

Schwieger, V., Zhang, L.: Automatisches geodätisches Monitoring mit Low-Cost GNSS. Messtechnik im Bauwesen, Spezial 2012, Verlag Ernst & Sohn, Berlin.

Zhang, L., Schwieger, V.: Investigation regarding different antennas Combined with low-Cost receiver. FIG Working Week, Abuja, Nigeria, 06.-10.05.2013.

Zhang, L., Schwieger, V.: Monitoring mit Low-Cost GPS Empfängern – Chancen und Grenzen. In: 124. DVW-Seminar: GNSS 2013 – Schneller, Genauer, Effizienter. Karlsruhe, 14.-15.03.2013.

Zhang, L.: Time-Spatial Analysis for Low-Cost GPS Time Series. In: Karpik, A., Schwieger, V., Novitskaya, A., Lerke, O. (Hrsg.): Proceedings on International Workshop on Integration of Point- and Area-wise Geodetic Monitoring for Structures and Natural Objects. SSGA, Novosibirsk, Russia, 2014.

Zhang, W., Zhang, L.: Time Series Analysis of Different Shieldings of Low-Cost GPS Receiver. Proceedings on 2nd International workshop on “Integration of Point- and Area-wise Geodetic Monitoring for Structures and Natural Objects”, March 23-24, 2015, Stuttgart, Germany

Zhang, L.: Reducing Multipath Effects by Considering Spatial Correlation. Proceedings on 2nd International workshop on “Integration of Point- and Area-wise Geodetic Monitoring for Structures and Natural Objects”, March 23-24, 2015, Stuttgart, Germany.

Zhang, L.; Schwieger, V.: Improving the Quality of Low-cost GPS Receiver Data for Monitoring Using Spatial Correlations. Journal of Applied Geodesy, Heft 2, de Gruyter, 2016.

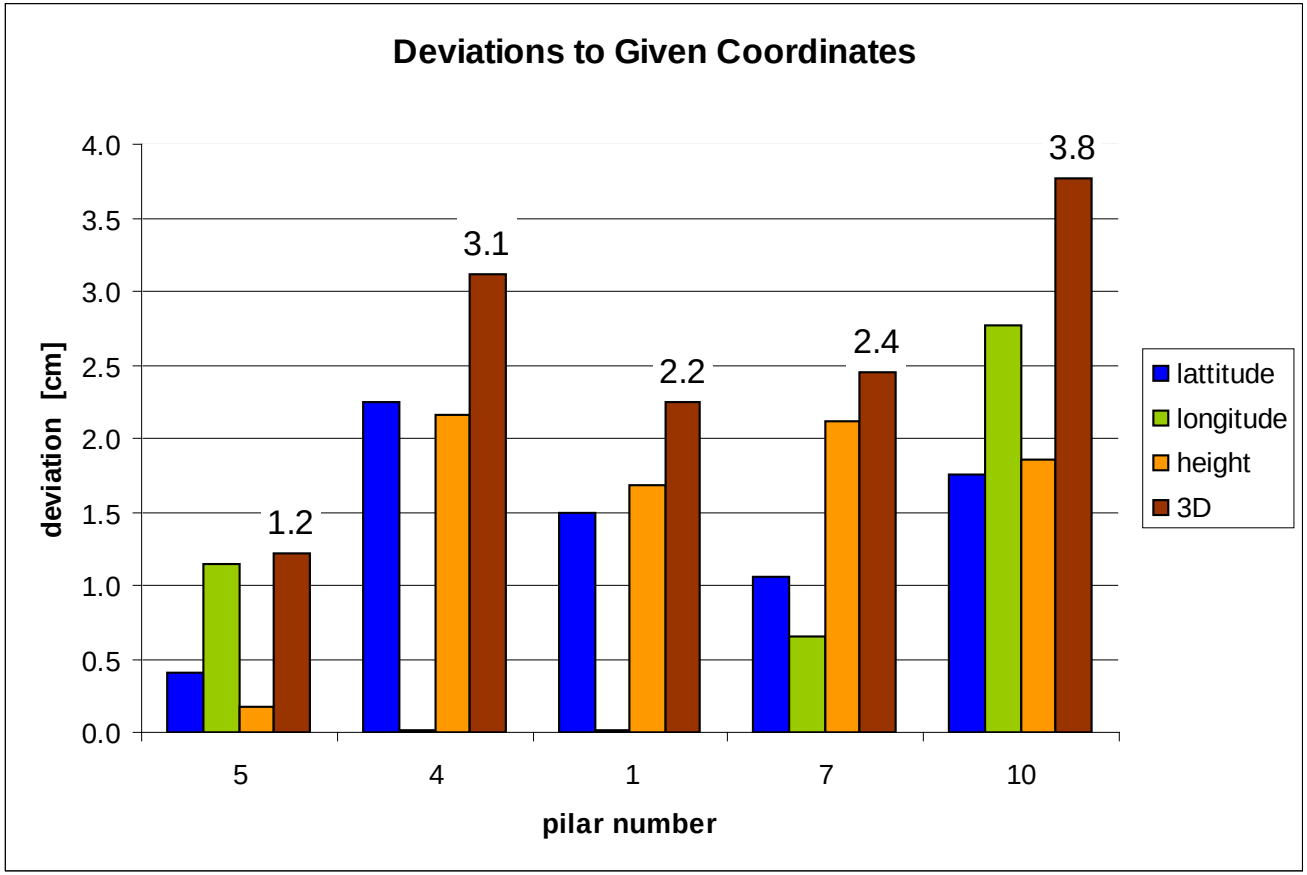
Zhang, Li: Qualitätssteigerung von Low-Cost-GPS Zeitreihen für Monitoring Applikationen durch zeitlich-räumliche Korrelationsanalyse, Dissertation (PhD –thesis)
Bayerische Akademie der Wissenschaften, Verlag C. H. Beck, DGK, Reihe C, Nr. 776

IIGS Research - History

First Publication at IIGS/IAGB:
Schwieger, V.: **Using Handheld GPS receivers for precise positioning.**
Proceedings on 2nd FIG regional conference, Marrakesh, Marocco, 2.-5.12. 2003.

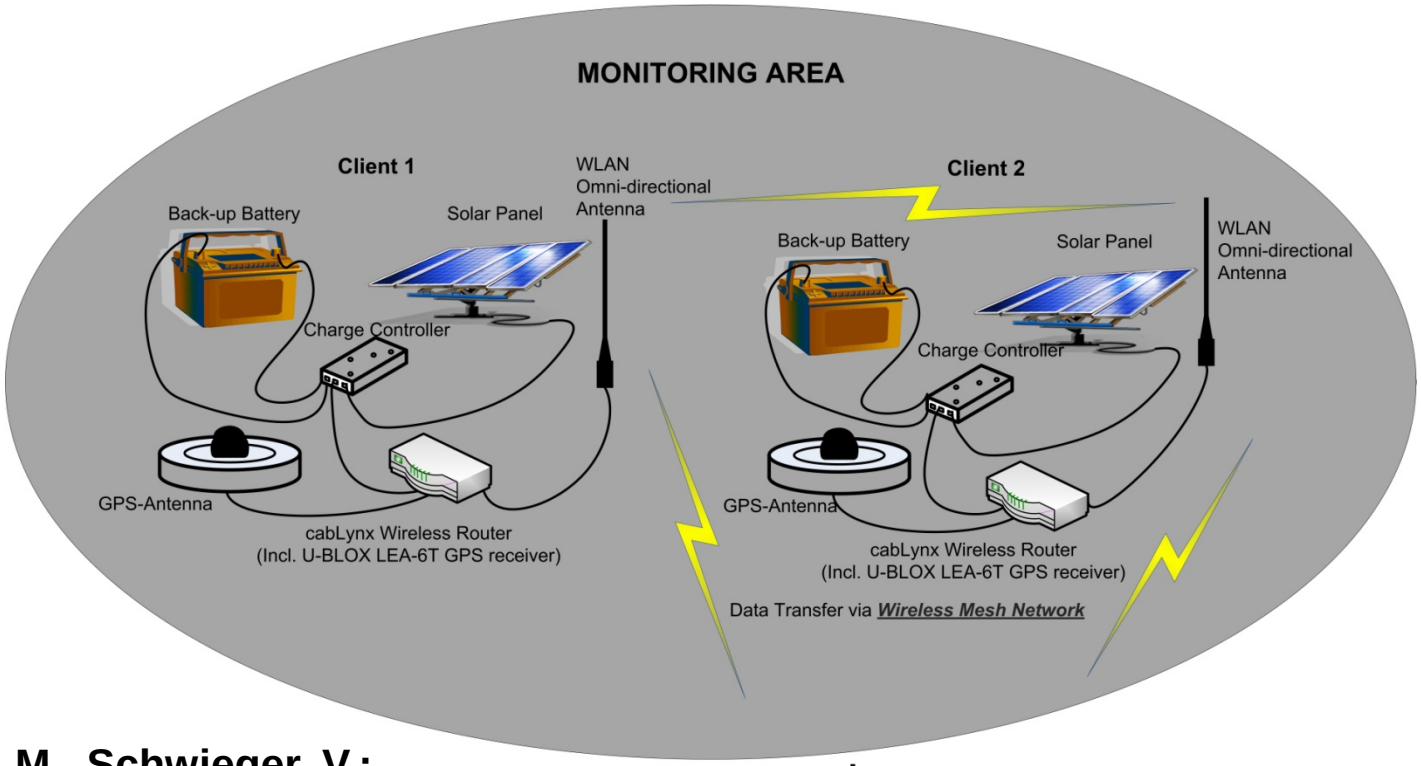
Next slide:
Schwieger, V.: **High-Sensitivity GNSS – the Low-Cost Future of GPS ?.**
Proceedings on FIG Working Week 2007, Hongkong SAR, 13.-17.05. 2007:

IIGS Research - History

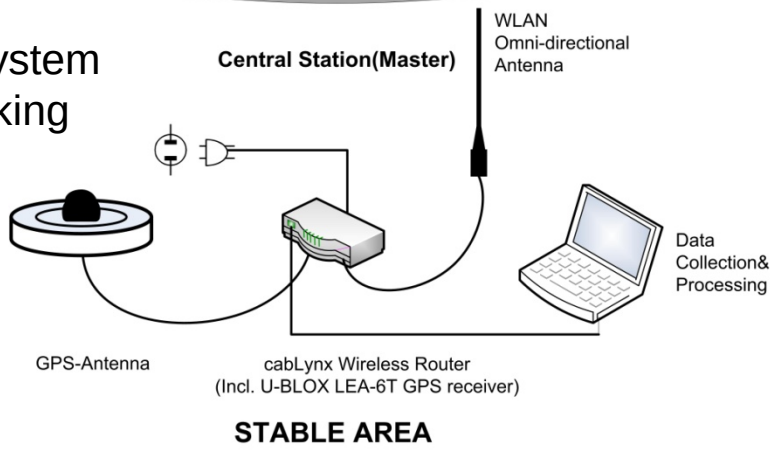


Standard deviation horizontal: 1.5 cm / vertical 2.0 cm!

IIGS Research - History



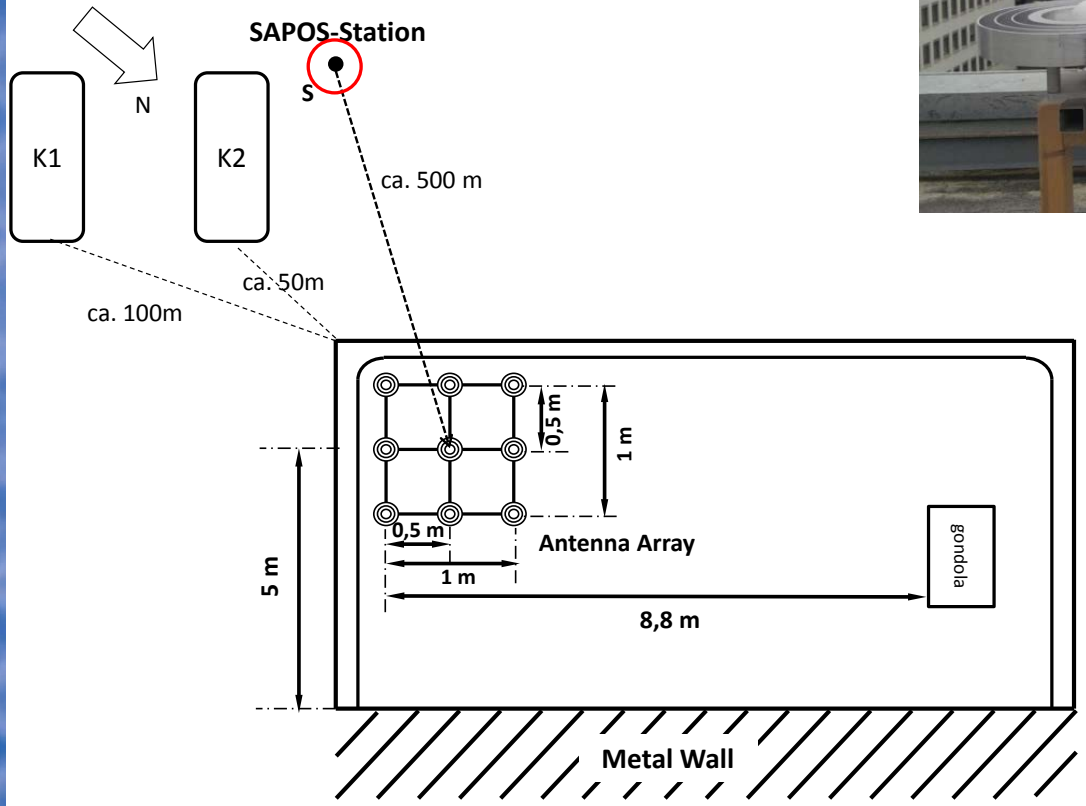
Zhang, L., Stange, M., Schwieger, V.:
Automatic Low-cost GPS Monitoring System using WLAN Communication. FIG Working Week, Rome, Italy, 06.-10.05.2012

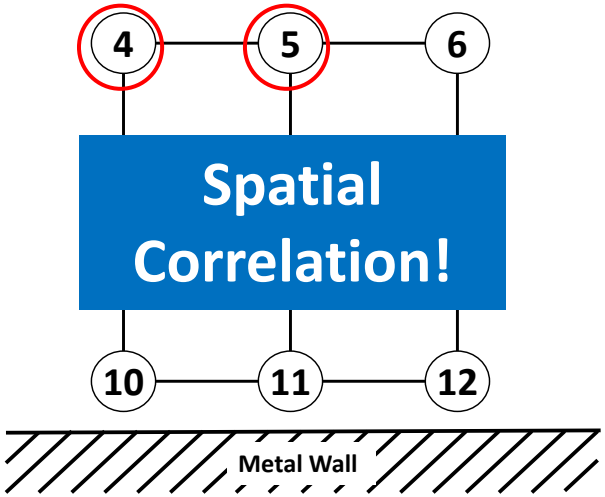


IIGS – Current Results

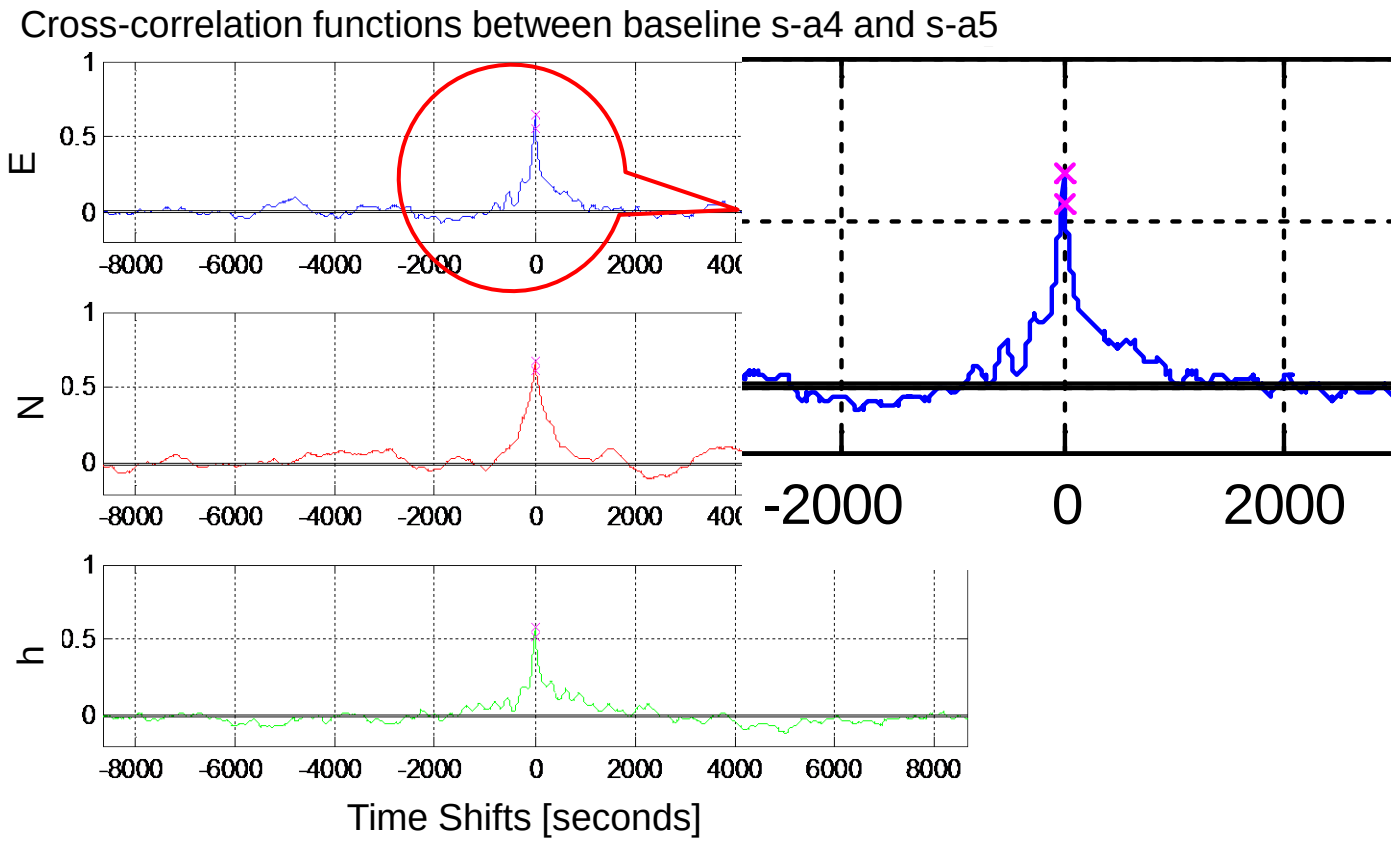
07.03-01.04.2014,9 stations (antenna array):

- u-blox EVK-6T single frequency GPS-receiver
- Trimble Bullet III Antenne
- self-constructed L1-optimized choke rings ground plane





Analysis of Temporal and Spatial Correlations



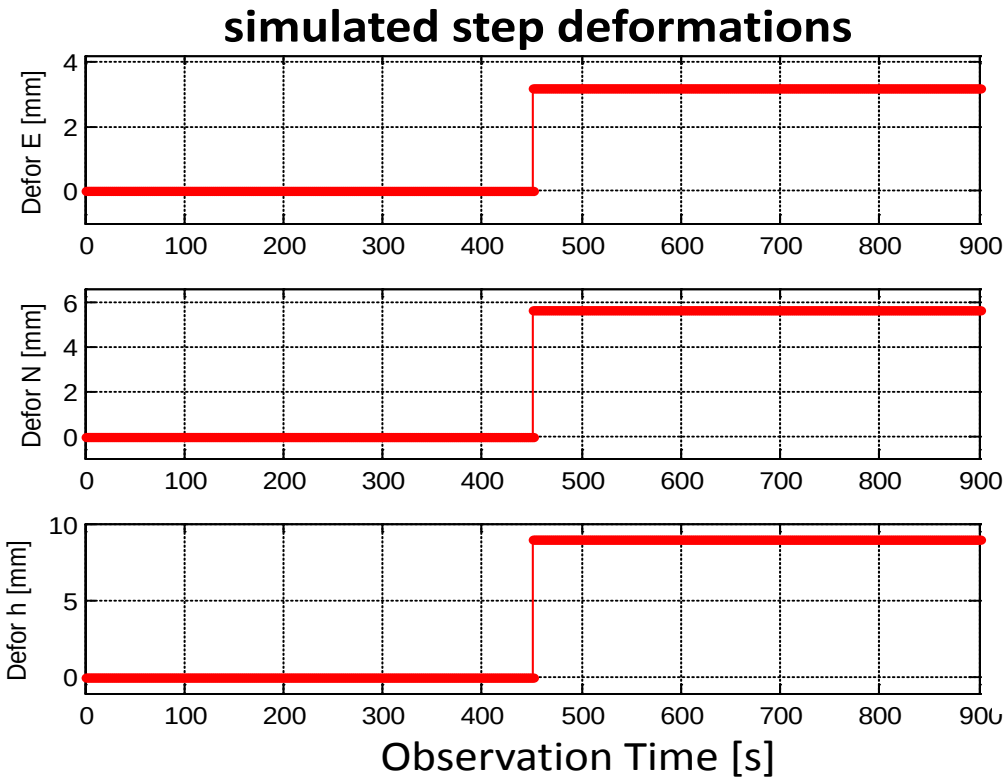
- Combination of white, red, colored noise (or non-correlating and correlating error)
- After 1000 seconds/ 15 minutes no correlations

Evaluation- simulated Deformation

- Measurement only on unmoved objekt (no deformation)

➔Evaluation by **simulated Deformation**

- Detection of step and linear deformations (landslides)

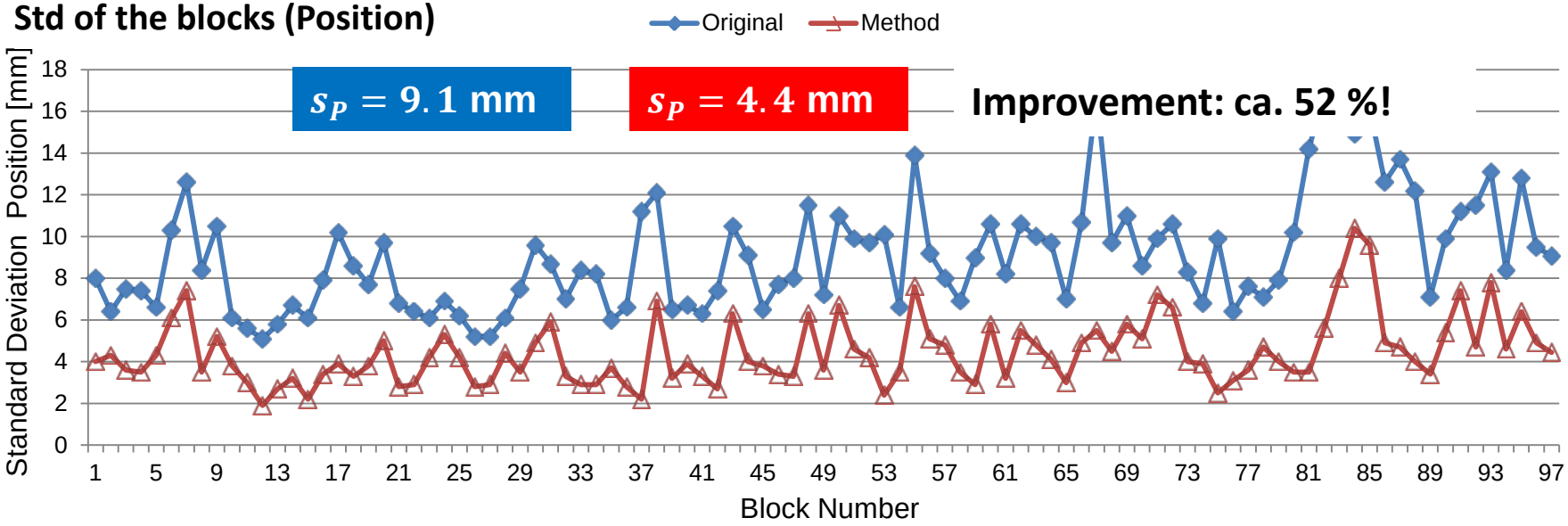


in middle of the 1. block, remain in other follwing blocks

- simulated step deformation: 1σ of Baseline s-a4: s_E= 3.2 mm, s_N = 5.6 mm, s_h = 9.0 mm, s_p = 11.0 mm

Evaluation- Results (s-a4 corrected by s-a5)

Std of the blocks (Position)

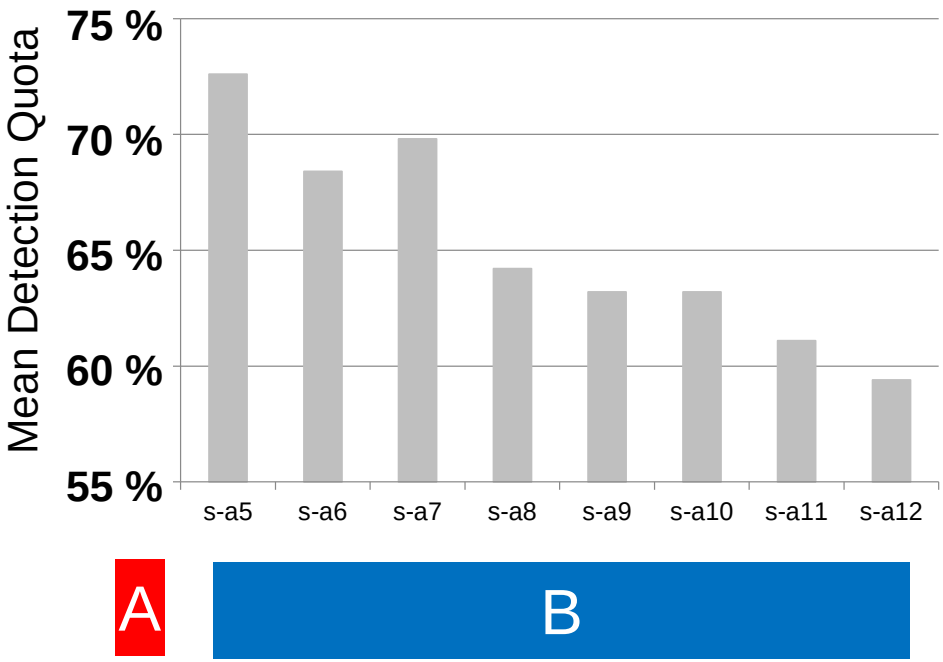


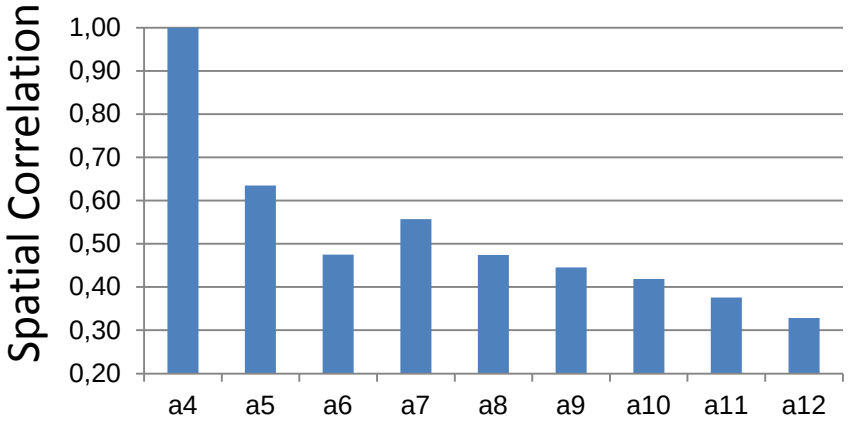
Detection Quota of Deformation (1σ)

Improvement: ca. 50 %!

Original				Method			
ζ_E	ζ_N	ζ_h	ζ_m	ζ_E	ζ_N	ζ_h	ζ_m
18.8 %	24.0 %	16.7 %	19.8 %	74.0 %	78.1 %	65.6 %	72.6 %

Evaluation- Results (s-a4 corrected by other baselines)





IIGS Research – Future Plans

Future Plans

- Low cost multiple GNSS
- Low cost multiple frequency GNSS
- mm-positioning in less than a minute
- Separation of deformations and multipath effects by adaptive bandpass filter
- Applications to monitoring and kinematic positioning
- Automation of processing and communication
- Development of prototypes, Commercialization

Thank you very much for your attention !

CONTACT

Prof. Dr.-Ing. habil. Volker Schwieger

Institute of Engineering Geodesy, University of Stuttgart
Geschwister-Scholl-Str. 24 D
70174 Stuttgart
Germany
Tel: +49-711-685-84040
Fax:+49-711-685-84044
E-mail: volker.schwieger@ingeo.uni-stuttgart.de