Universität Stuttgart
Institute of Engineering Geodesy (IIGS)

Monitoring of Rock Fall at Yangtze River with Low-Cost GNSS receiver

Dr.-Ing. Li Zhang

Institute of Engineering Geodesy (IIGS),

University of Stuttgart, Germany

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"Modern Geodetic Space Techniques

for Global Change Monitoring"

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Introduction

Table 1: Receiver classes, applications and accuracy levels of static positioning

receiver class	used signal	applications	accuracy	appr. costs
low cost	code or phase-smoothed code, 1 frequency	car navigaton, location based services, sailing, mass market	1 to 10 m	100 – 500 €
geodata acquisition	phase-smoothed code, 1 frequency	infrastructure planning, architecture, GIS applications	0,5 to 3 m	5 000 – 10 000 €
geodetic	code and phase, in general 2 frequencies	surveying, geodynamics	0,001 to 0,1 m	10 000 € - 30 000 €

Schwieger and Gläser (2005)

EVK-M8
www.u-blox.com

Leica GS25
www.leica-geosystems.com

Low-Cost GNSS Receiver for Geodetic Applications, e.g. for monitoring, and machine control (Accuracy: mm to cm-level)?

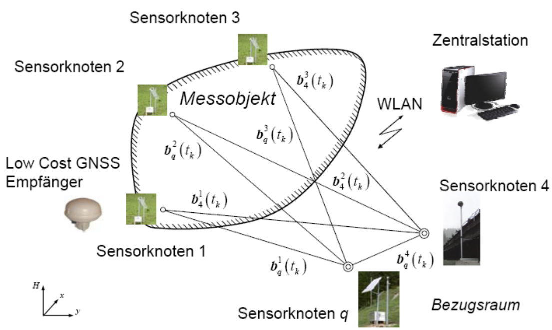
Carrier Phase measurements should be accessible!

Introduction

Test study with u-blox GPS receivers at University of Stuttgart, ETH Zurich und TU Graz

Schwieger (2009), Uni Stuttgart   Lanzendörfer (2007), TU Graz   Limpach (2009), ETH Zürich

The University of Armed Forces Munich with Novatel GNSS receivers (about 1200€)



Heunecke etal. (2011), Uni BW München

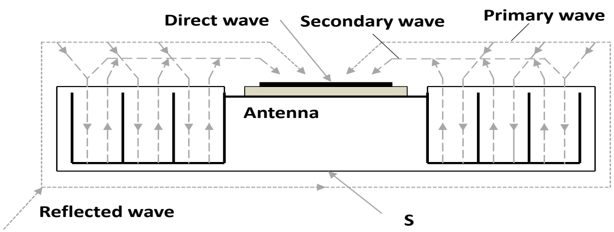
Low Cost GNSS is suitable for the monitoring applications, length - dependent error (tropospheric, ionospheric) are reduced for short baseline in relative module.

Geodetic Application: Monitoring

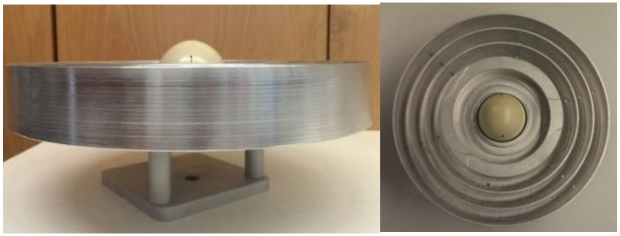
Dominate error for short baseline: Multipath effect

- Reduced by data processing (e.g. temporal and spatial correlations)
- Good antennas are important (e.g. Trimble Bullet III vs. Ublox ANN-MS, see Takasu and Yasuda 2008, Zhang and Schwieger 2013)
- Optimization of antenna shielding (ground plate vs. choke ring)

*Originally developed by **JPL***



Zhang (2016)



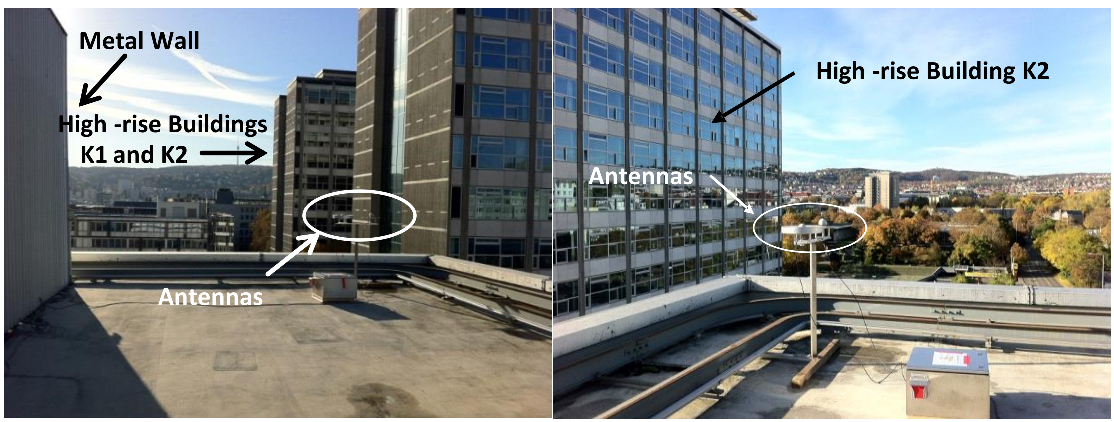
self-constructed L1-optimized CR-GP at IIGS
with Trimble Bullet III antenna (side view and top view)

- Groove depth: ¼ of wave length
- Diameter: 1.5 of wave length

Comparison of different Shieldings

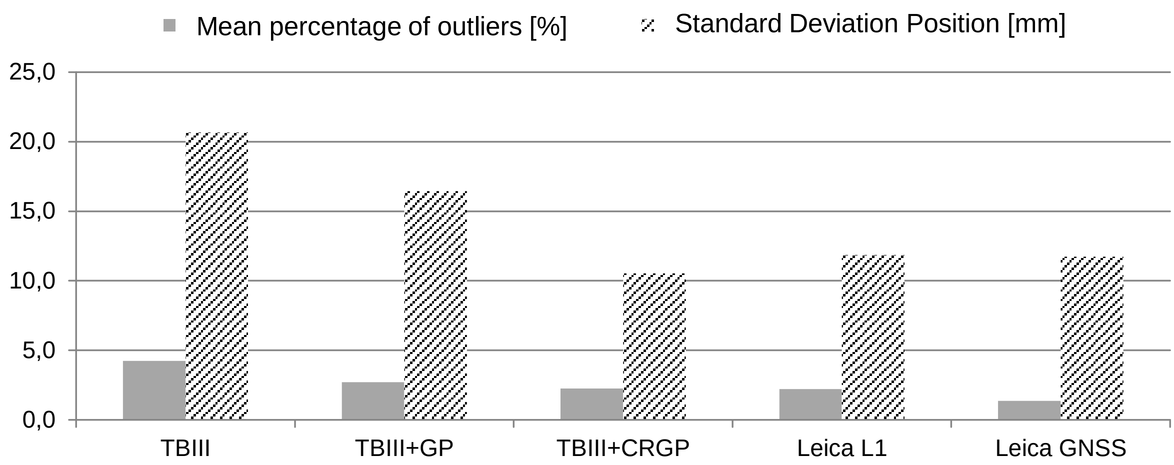
No shielding	Flat ground plane	Choke Ring ground plane	Leica

1) TBIII antenna without shielding + Ublox LEA-6T single-frequency GPS receiver,
2) TBIII antenna with flat GP + Ublox LEA-6T single-frequency GPS receiver,
3) TBIII antenna with CR-GP + Ublox LEA-6T single-frequency GPS receiver,
4) Leica AX1203 GNSS antenna without additional shielding + Leica GX1230 GNSS receiver.



Comparison of different Shieldings

Quality Analysis



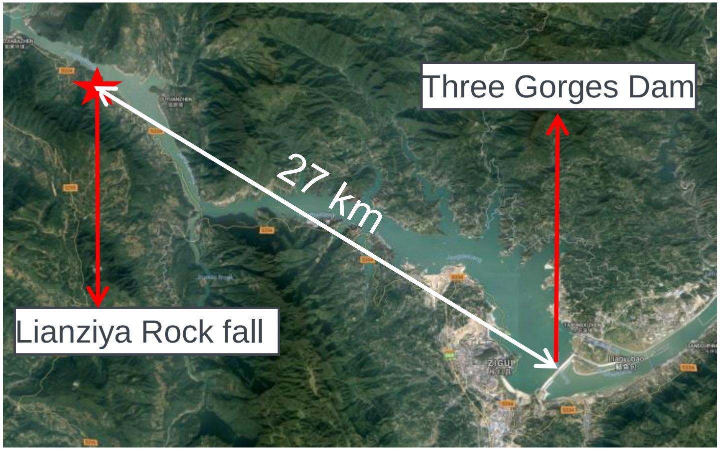
- Improvement of the std.: Flat GP: 35 %, CR-GP: ca. 50 %
- TBIII with CR-GP std. ca. 3/5/9 mm (E/N/h) in this reflexion intensive environment
- TBIII with CR-GP comparable with Leica AX 1203 antenna with GX1230 receiver in this test

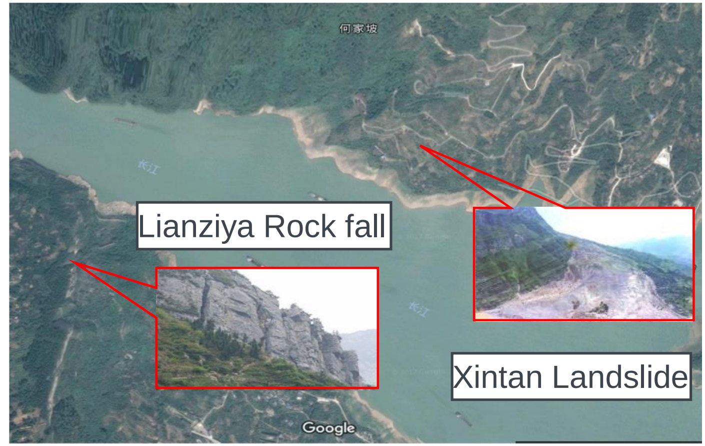
DAADCSC PPP Project

Project: Automatic Multisensor Early Warning System near the Three Gorges Dam

- Funded by China Scholarship Council (CSC) and German Academic Exchange Service (DAAD) within Project Based Personnel Exchange Program (PPP)
- Duration: 2017-2018 (2 years), possible extension for 1 year (2019)
- Partner: - Institute of Engineering Geodesy (IIGS), University of Stuttgart, Project leader: Prof. Volker Schwieger
  - Institute of Surveying Engineering, School of Geodesy and Geomatics (SGG), Wuhan University, Project leader: Prof. Yaming Xu
- Goal: development of cost effective automatic Multisensor Early Warning System

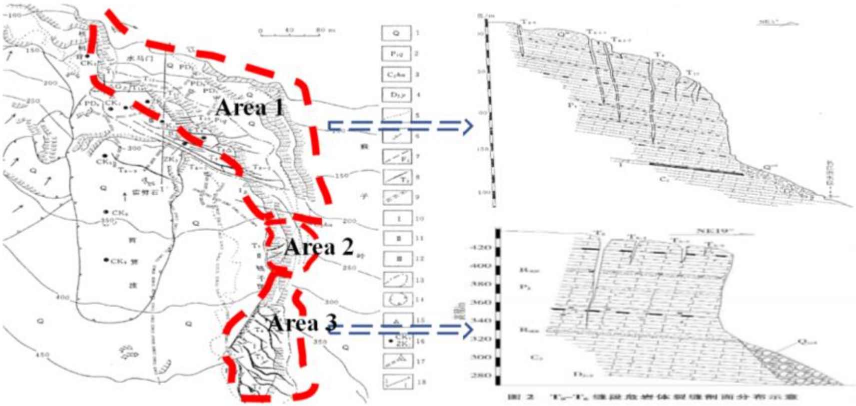
Test Area: Lianyiya Rock Fall





Introduction and motivation

- Causes of rock fall
  - Active geological structure
  - Change of water level
  - Coal mining
- Three areas according to:
  - Geological structures
  - Topography
  - Characteristics of movement



- Stabilization of area 1 through constructive measures
- Area 3 still active
  - Average horizontal displacement 1.0~4.2 mm/year
  - Average vertical 0.3~2.9 mm/year
- Direct threat to the shipping on Yangtze River and the surrounding towns!

Instruments

- GB-Radar (IBIS-L)
- GNSS (U-blox C94-M8P RTK Application Board, Leica 1200 System)
- TLS (Leica P50)

- 2 Neo-M8P-2 GNSS (GPS, GLONASS, Beidou, QZSS) modules
- 2 GNSS antennas + ground plate
- 2 UHF antennas

(~350€)

Monitoring of Rock fall at the Yangtze River near the Three Gorges Dam with U-blox C94-M8P

Measurement

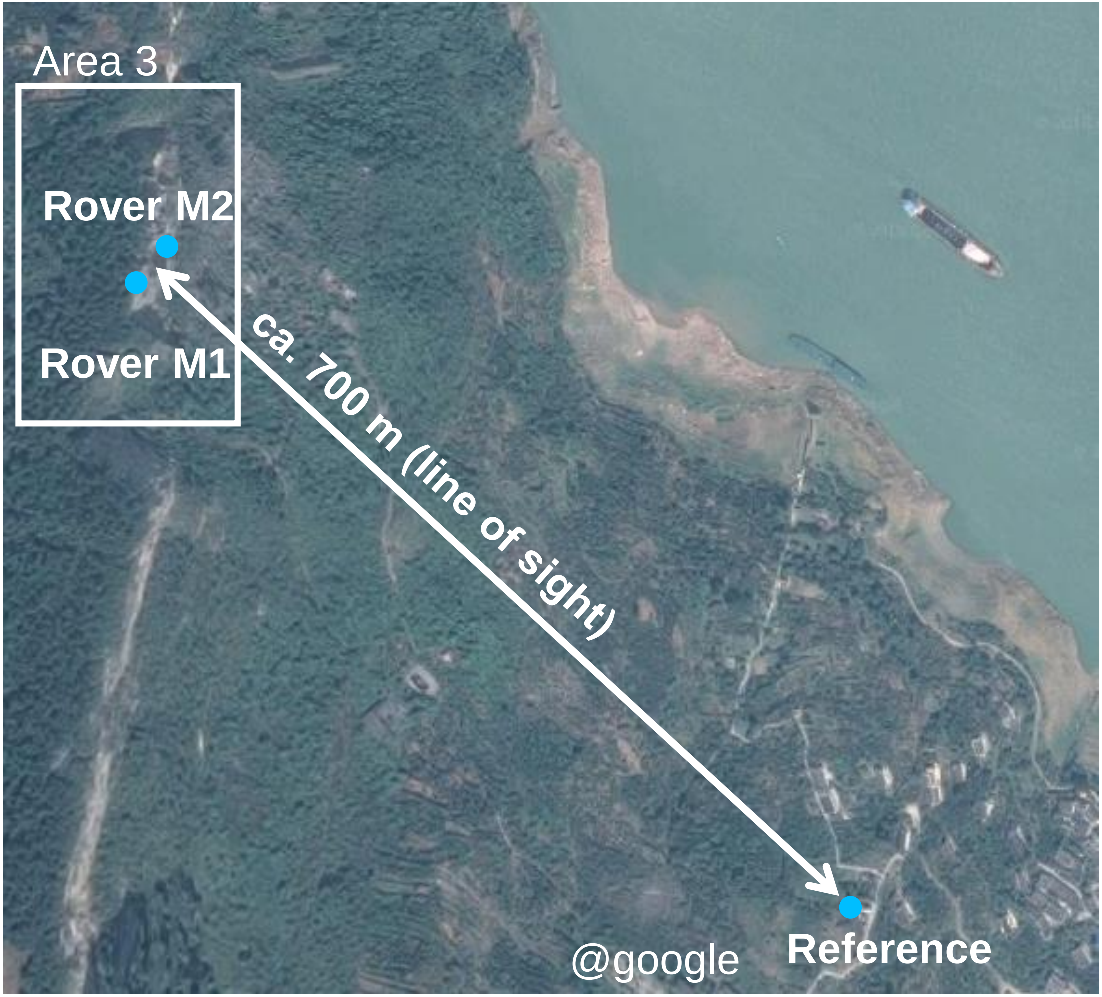
Reference Station (R)

Rover Station (M1)

Rover Station (M2)

- Leica 1200 System (GPS only)
- Ublox C94-M8P application Board (GPS+Beidou)

Test Area


Area 3
Rover M2
Rover M1
ca. 700 m (line of sight)
@google
Reference

Monitoring of Rock fall at the Yangtze River near the Three Gorges Dam with U-blox C94-M8P

Results – Baseline (Post-Processing)

Date	Session	Reference Station	Rover Station	Baseline [m]		
				E [m]	N [m]	h [m]
09 March, 2018	1 (9:20-11:20)	Leica (R)	Ublox(M1)	423.3217	-534.7675	205.4940
		Leica (R)	Leica (M2)	401.0503	-546.9636	211.8549
	2 (14:00-16:00)	Leica (R)	Leica (M1)	423.3213	-534.7696	205.5032
		Leica (R)	Ublox(M2)	401.0518	-546.9635	211.8593
10 March, 2018	3 (10:15-12:15)	Ublox (R)	Ublox(M1)	423.3161	-534.7708	205.5010
		Ublox (R)	Leica (M2)	401.0419	-546.9685	211.8532
	4 (14:14-16:14)	Ublox (R)	Leica (M1)	423.3129	-534.7727	205.5002
		Ublox (R)	Ublox(M2)	401.0430	-546.9649	211.8572

The difference of the Baselines is under 1 cm in all the coordinate components

Monitoring of Rock fall at the Yangtze River near the Three Gorges Dam with U-blox C94-M8P

Results - Standard Deviation (Post-Processing)

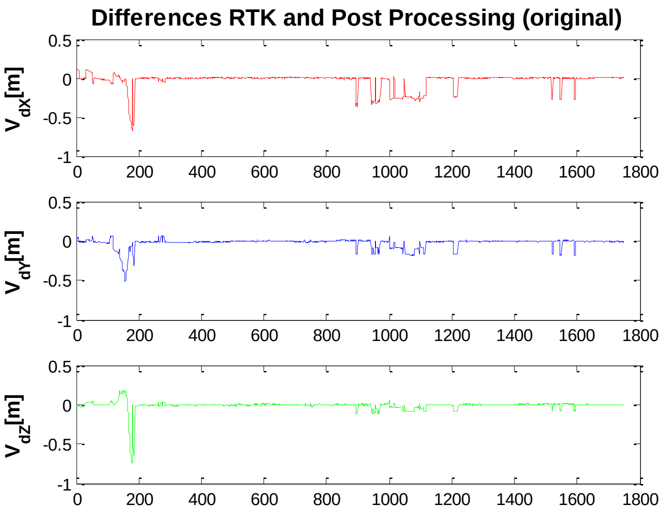
Date	Session	Reference Station	Rover Station	Standard Deviation [mm]		
				E [mm]	N[mm]	h[mm]
09 March, 2018	1 (9:20-11:20)	Leica (R)	Ublox(M1)	5.2	3.7	11.1
		Leica (R)	Leica (M2)	5.3	3.7	11.4
	2 (14:00-16:00)	Leica (R)	Leica (M1)	3.8	4.0	12.3
		Leica (R)	Ublox(M2)	3.9	3.6	9.1
10 March, 2018	3 (10:15-12:15)	Ublox (R)	Ublox(M1)	3.7	2.7	9.7
		Ublox (R)	Leica (M2)	4.8	3.3	13.3
	4 (14:14-16:14)	Ublox (R)	Leica (M1)	3.9	3.9	9.6
		Ublox (R)	Ublox(M2)	2.8	2.4	7.3

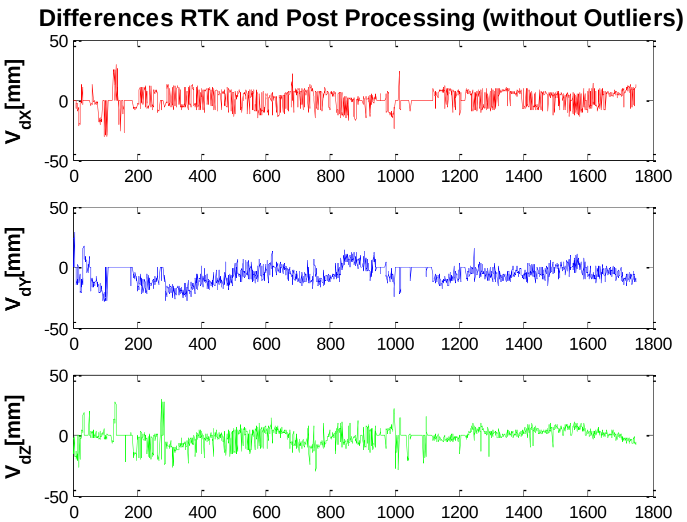
- Baseline R-M1 (Leica-Leica vs. Ublox-Ublox: 13.5 mm vs. 10.8 mm) for whole position
- Baseline R-M2 (Leica-Leica vs. Ublox-Ublox: 13.1 mm vs. 8.1 mm) for whole position
- Advantage of GPS + Beidou Combination
- Short baseline (700 m)

Postprocessing vs. RTK results (u-center)

3. Session on 10. March 17:00-17:30 for testing RTK Performance

ca. 15% outliers

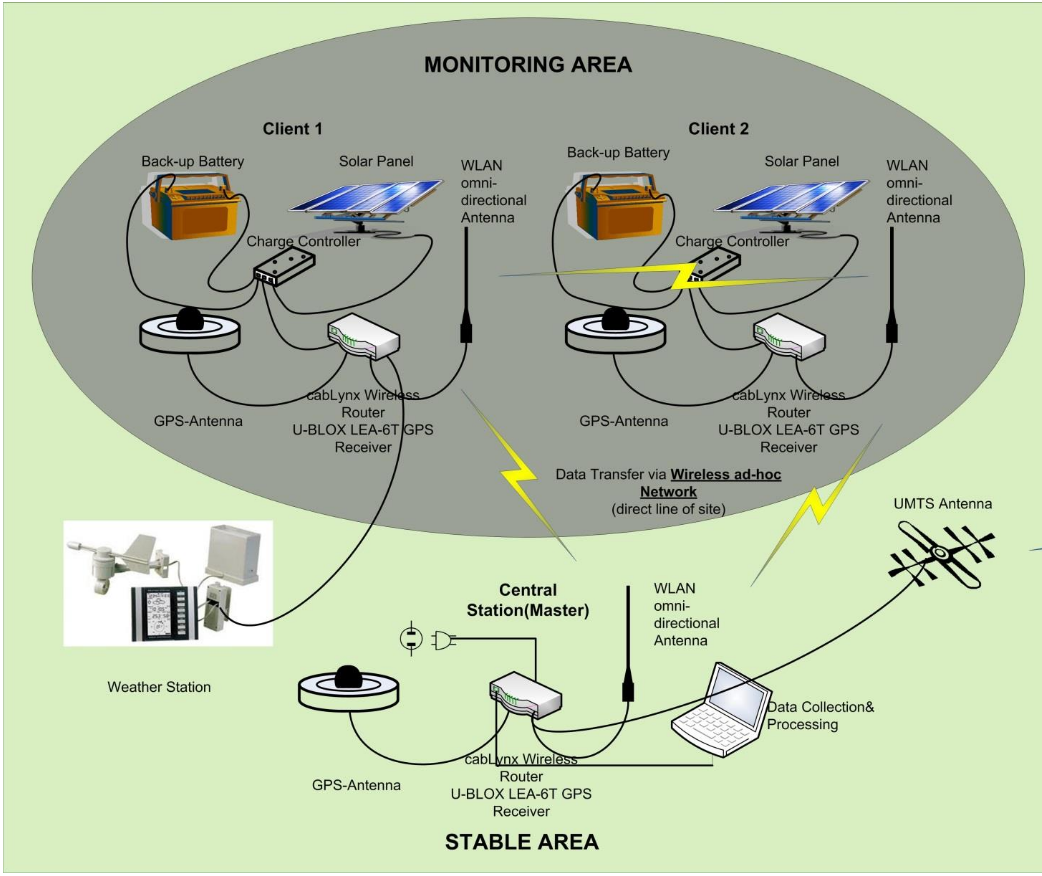




Standard Deviation	X [mm]	Y [mm]	Z [mm]
Original	97.8	61.9	65.3
Without outlier	7.2	7.3	6.9

Geodetic Application: Monitoring

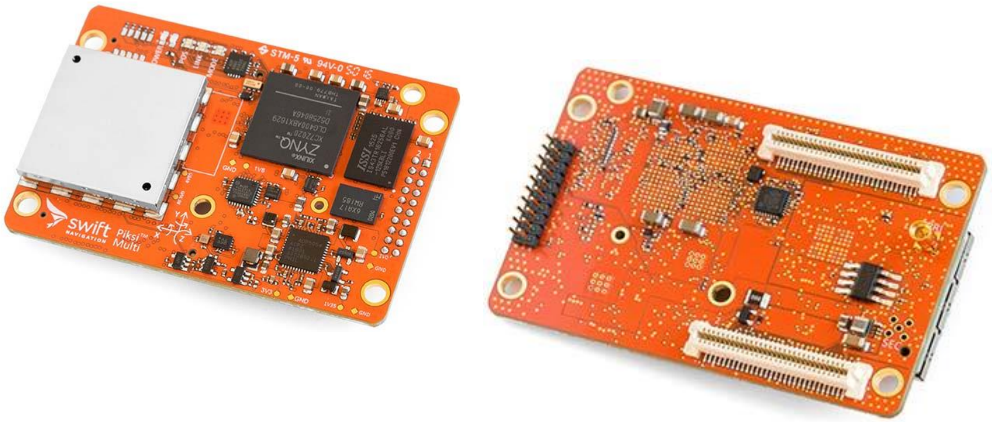
Automatic Low-Cost GPS Monitoring System at IIGS (2012)



u-blox LEA-6T GPS receiver

Outlook

Low-Cost multi-frequency GNSS Receiver?



Piksi Multi GNSS Module
https://www.swiftnav.com

~$600

GPS L1+L2
(Hardware-ready for GLONASS G1+G2, BeiDou B1+B2, Galileo E1+E5b, QZSS L1+L2 and SBAS)

Outlook

Low-Cost multi-frequency GNSS Receiver?

ublox

Products Support Beyond Investors

Technology | 22 February 2018

High precision positioning

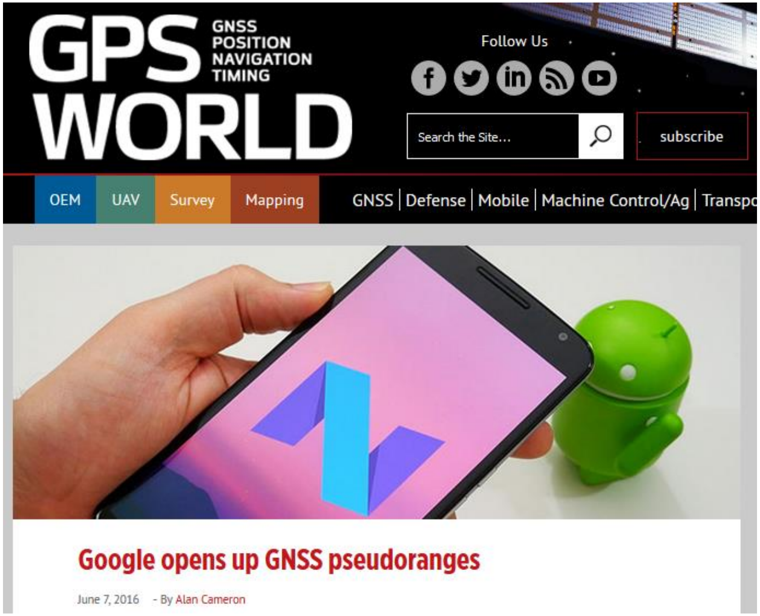
Achieving centimeter-level accuracy by combining RTK technology and u-blox GNSS expertise.

GPS L1+L2
Galileo: E1+E5

Outlook

GNSS Raw measurements of smartphone are accessible!

„Google announced that raw GNSS measurements will be available to apps in the Android N operating system” (May/June 2016)



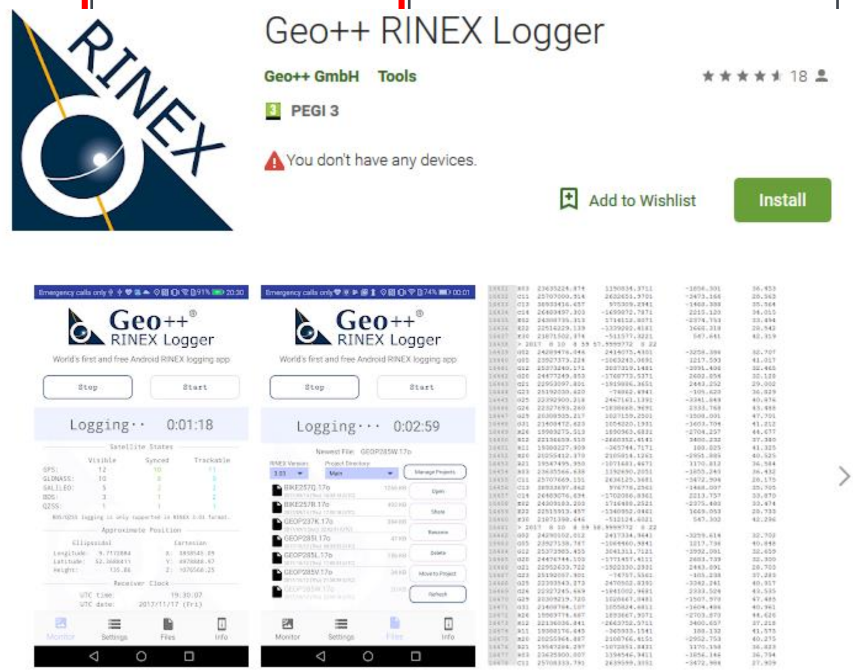
http://gpsworld.com/google-opens-up-gnss-pseudoranges/

Outlook

GNSS Raw measurements of smartphone are accessible!

Carrier Phase

Model	Pseudorange data	Accumulated delta range	Global systems
Huawei Mate 10	yes		
Huawei P10	yes		
Huawei Honor 9	yes		
Samsung S8 (Exynos)	yes		
Nexus 9 (non cellular version)	yes		



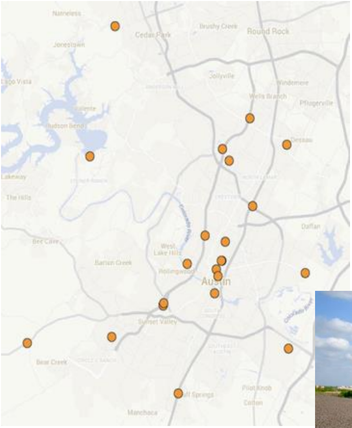
Selectived from https://developer.android.com

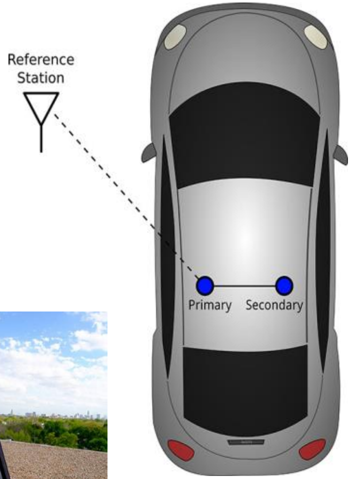
Better oder external antenna?

Outlook

Precise Positioning with Low-Cost GNSS for automated vehicles?

A dense reference network (20 km) facilitates low-cost carrier-phase differential GNSS positioning with rapid integer-ambiguity resolution (PPP-RTK), centimeter-accuracy can be achieved.





Murrian et al. (2016)

Outlook

ublox

Products Support Beyond Investors

Home →
Bosch, Geo++, Mitsubishi Electric und u-blox gründen gemeinsam das Joint Venture Sapcorda Services, das GNSS-Positionierungsdienste mit hoher Präzision für Massenmärkte bereitstellen soll →
Bosch, Geo++, Mitsubishi Electric and u-blox to establish joint venture Sapcorda Services to bring high precision GNSS positioning services to Mass Markets

Investor press releases | 08 August 2017

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Bosch, Geo++, Mitsubishi Electric and u-blox to establish joint venture Sapcorda Services to bring high precision GNSS positioning services to Mass Markets

Bosch, Geo++, Mitsubishi Electric and u-blox today announced the creation of Sapcorda Services GmbH, a joint venture that will bring high precision GNSS positioning services to mass market applications

Summary

- Low Cost GNSS receivers are suitable for the monitoring application (accessible carrier-phase raw measurement, reliable antenna or use shielding)
- Low Cost GNSS receivers are more and more cheaper, they are not limited to single-frequency, single-system
- Carrier-phase raw measurement are accessible from some smartphones, precise positioning could be possible with smartphones (sensor intergration, reliable antenna)
- Precise Positioning with Low-Cost GNSS for automated driving should be possible (PPP-RTK, reliable facilities, low-cost and reliable GNSS antenna)

Acknowledgement

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Vielen Dank! Thank you!

Dr.-Ing. Li Zhang

E-Mail li.zhang@iigs.uni-stuttgart.de
Telefon +49 (0) 711 685-84049
www.uni-stuttgart.de/ingeo

Universität Stuttgart
Institute of Engineering Geodesy
Geschwister-Scholl-Str.24D
70174 Stuttgart