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Interexpo GeoSiberia

International Federation of
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FIG

AN OVERVIEW OF COST EFFECTIVE TECHNOLOGIES FOR HIGH-PRECISION POSITIONING

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Cost Effective Positioning and Geo Data Seminar

20th April 2017, Novosibirsk

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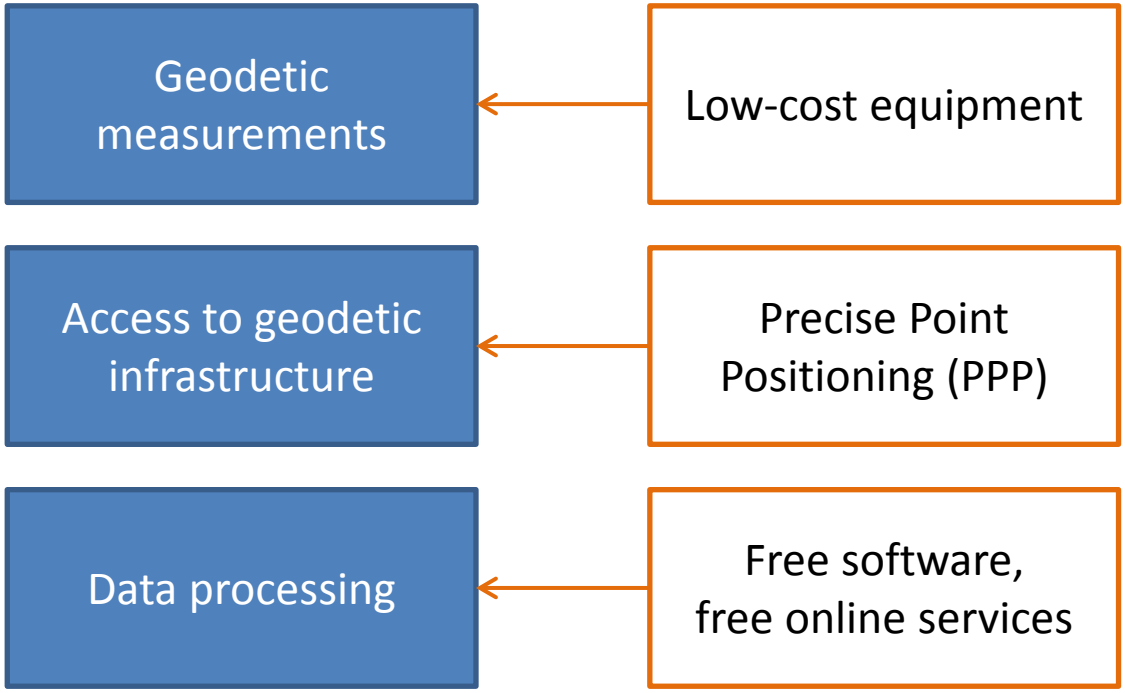
- Introduction
- Low-cost GNSS equipment
- Free software
- Online services for precise positioning
- Precise Point Positioning using SBAS (WAAS, QZSS, SDCM)
- Opportunities and urgent tasks

INTRODUCTION

The main items of expenses which could be optimized by improving technology:

- Working hours
- Investments in means of labor including hardware and software
- Costs of infrastructure, i. e. costs of access to GNSS continuously operating reference stations data or to commercial SBAS

SOME MEANS OF IMPROVING COST EFFICIENCY



LOW COST GNSS EQUIPMENT

- Mobile communication devices, including smartphones and tablet PC with navigation modules

- Telematic systems for transport monitoring

- Dedicated handheld and car navigation devices

AN EXPERIMENT ON LOW COST EQUIPMENT ACCURACY ASSESSMENT

Low Cost Hardware

Prototype of transport monitoring device manufactured by NTP «STATT»

- GNSS module NV08C-CSM
- GNSS antenna NV2410
- Wi-Fi module

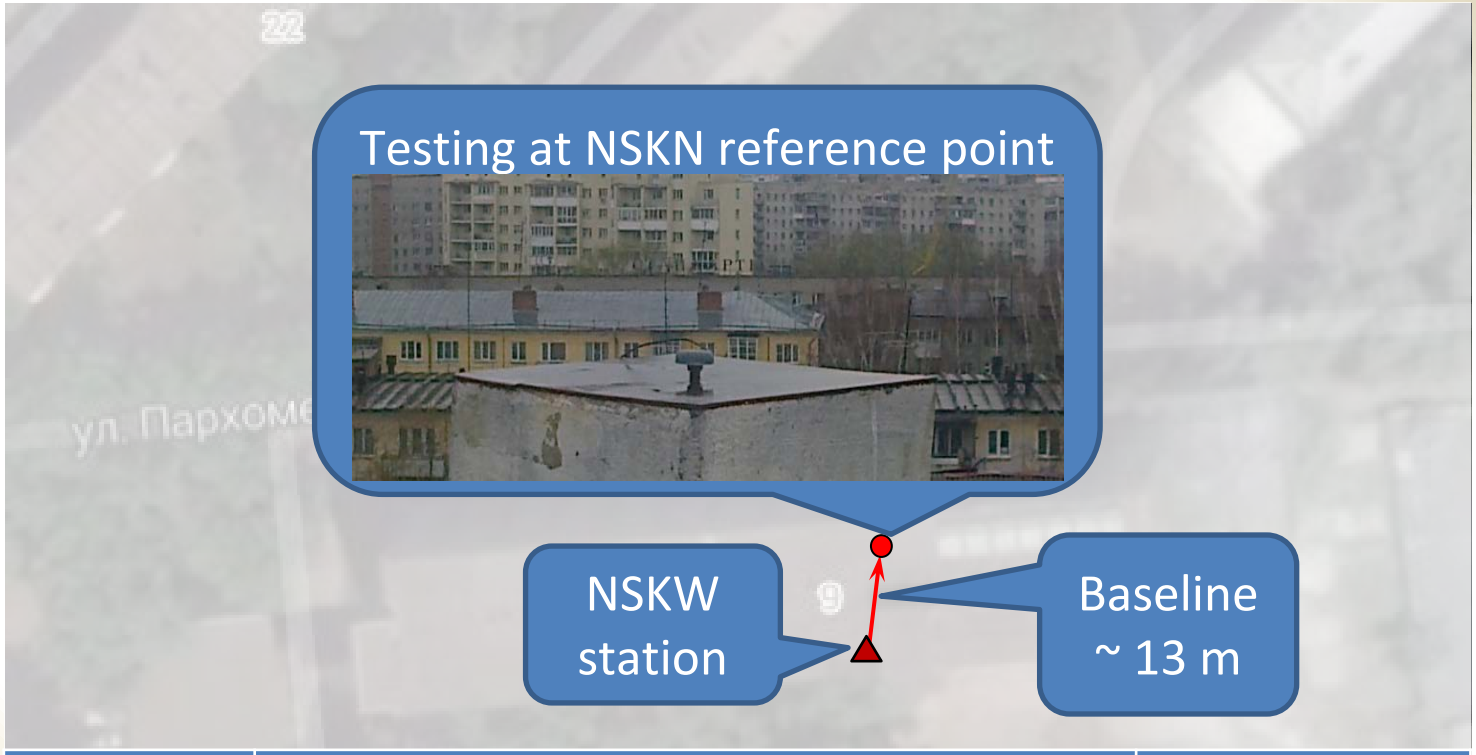
Improved* Free Open Source Software

RTKLIB 2.4.2

- Kalman filter
- PPP, RTK

* Added half-cycle slip handling feature

AN EXPERIMENT ON LOW COST EQUIPMENT ACCURACY ASSESSMENT

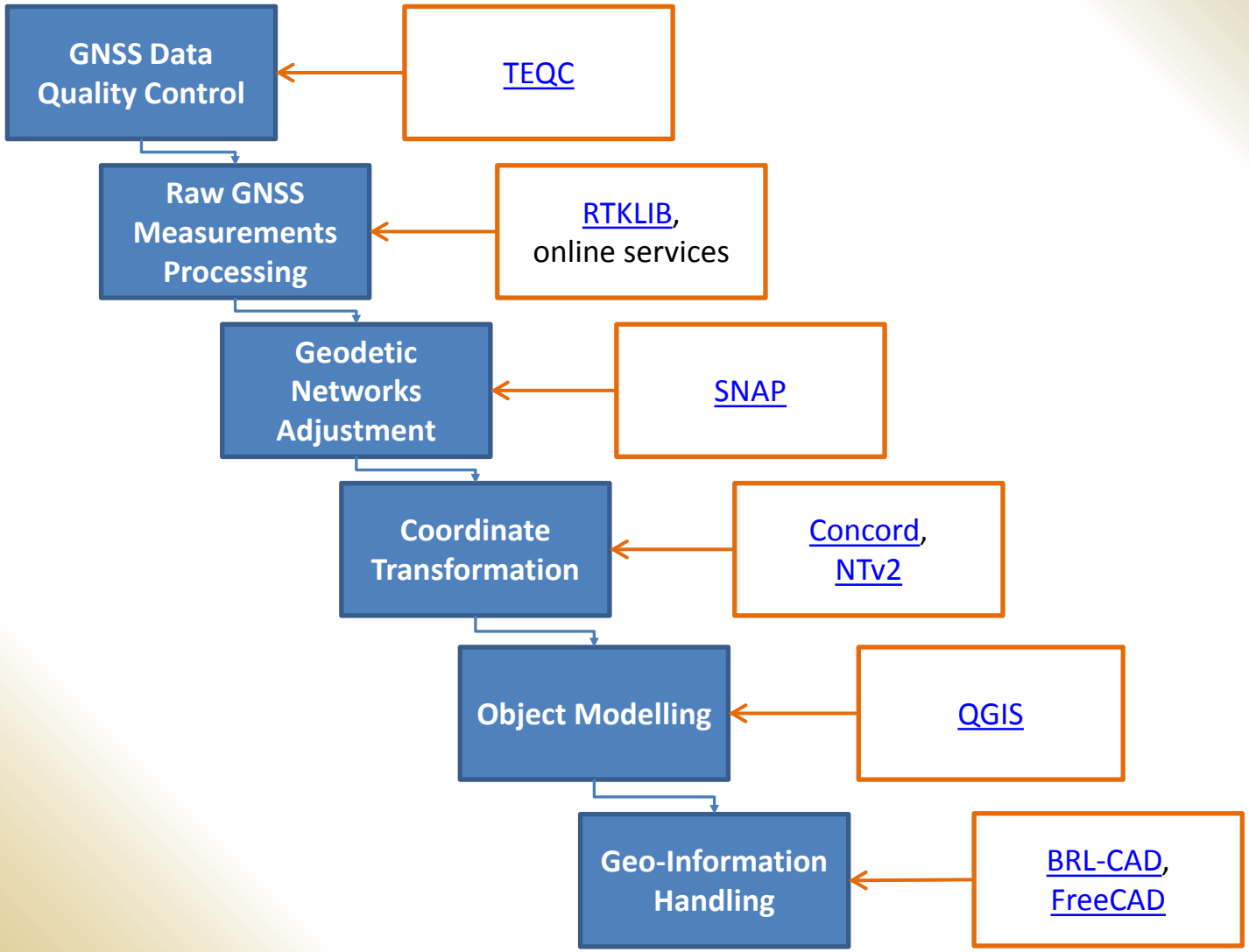


GNSS	Root Mean Square Error, м				Outliers excluded (> 30 cm)
	E	*N*	*U*	*3D*	
GPS	*0.009*	*0.012*	*0.015*	*0.021*	*1 %*

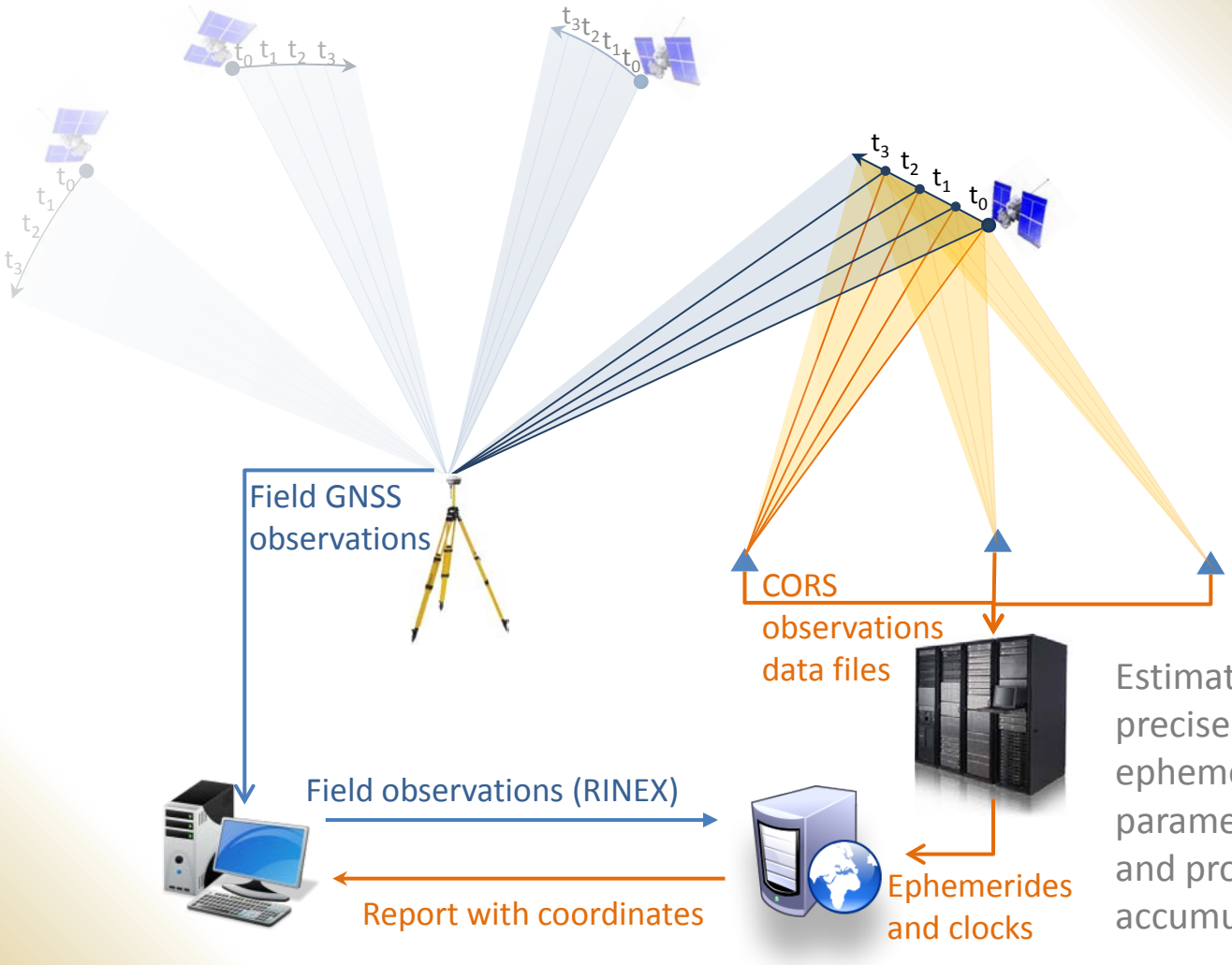
FREE SOFTWARE

Free software, **freedom-respecting software**, or **software libre** is computer software distributed under terms that allow the software users to run the software for any purpose as well as to study, change, and distribute the software and any adapted versions. Free software is a matter of liberty, not price: users, individually or collectively, are free to do what they want with it, including the freedom to redistribute the software free of charge, or to sell it, or charge for related services such as support or warranty for profit. [Wikipedia]

Example of Data Processing Workflow Relying on Free Software



ONLINE SERVICE FOR GNSS OBSERVATION POST-PROCESSING



Observation of GNSS satellites by globally spaced network of continuously operating reference stations (CORS)

Estimation of precise clock and ephemerides parameters, data and products accumulation

Estimation of coordinates by online service

ONLINE SERVICES FOR PRECISE POSITIONING BY USER'S GNSS OBSERVATION FILE

Free online services for precise coordinates determination based on **Precise Point Positioning (PPP)**:

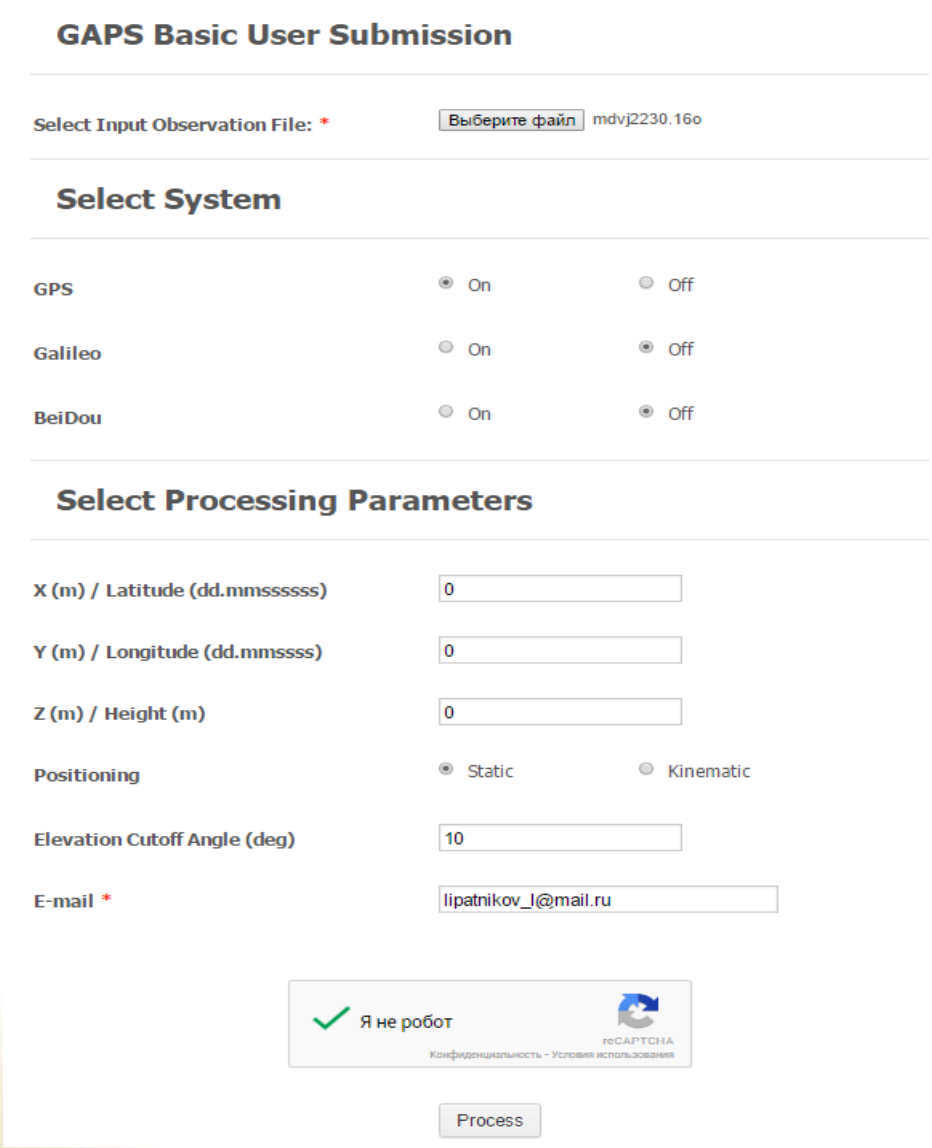
Online Service	Origin	GNSS
APPS	USA, Jet Propulsion Laboratory, NASA	GPS, GLONASS, BeiDou, (Galileo to be added soon)
CSRS-PPP	Natural Resources Canada (NRCan)	GPS, GLONASS
GAPS	Canada, University of New Brunswick	GPS, Galileo, BeiDou
Magic GNSS	Spain, GMV	GPS, GLONASS, Galileo

Services implementing **relative positioning** which provide global coverage due to utilizing of IGS network and capability to process very long baselines.

Online Service	Origin	GNSS
AUSPOS	Australia, Geoscience Australia	GPS
ВМ СДКМ	Russia, Russian Space Systems	GPS, GLONASS
ИАЦ КВНО	Russia, Information and Analysis Center for Positioning, Navigation and Timing	GPS, GLONASS

Similar services, enabling relative positioning within coverage are of national CORS networks exist in Germany (SAPOS-GPPS), New Zealand (PositionNZ-PP), USA (OPUS)... Most of them are also free of charge (SAPOS is an exception).

ONLINE SERVICE FOR GNSS OBSERVATION POST-PROCESSING GAPS

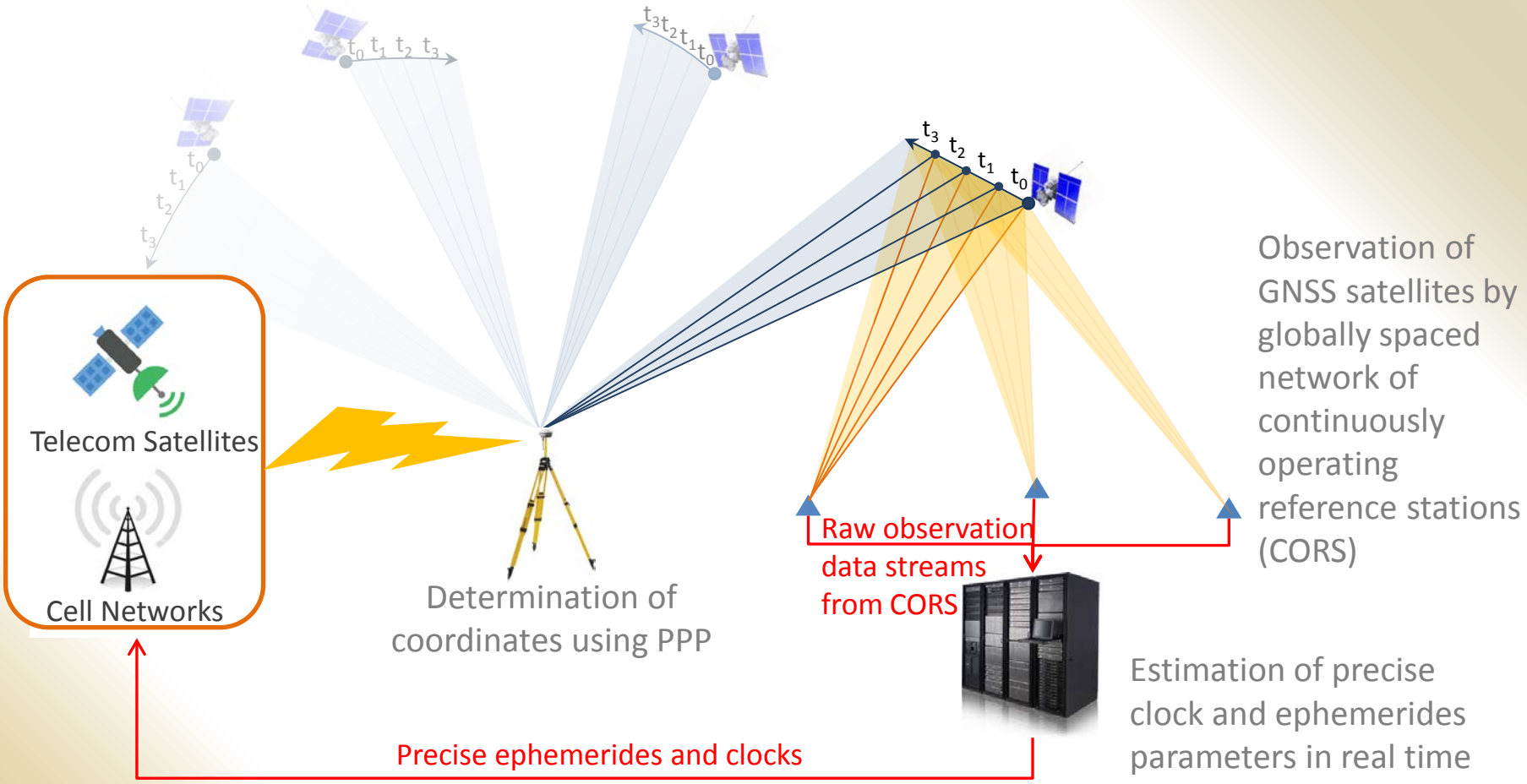


FREE SOFTWARE AND ONLINE SERVICE: PPP POST-PROCESSING RESULSTS

Deviation of estimate from ITRF2008	GAPS online service. Static mode	RTKLIB Software Static mode
East, m	0.013	-0.010
North, m	0.002	-0.005
Up, м	-0.008	-0.017
3D, м	0.015	0.020

Coordinates of Mendeleevo (MDVJ) IGS station were determined as a result of daily RINEX observation data file processing for the 10th August 2016 using PPP.

REAL-TIME PRECISE POINT POSITIONING



SOME FREE RTCM SSR DATA SOURCES FOR REAL-TIME PPP

Data Source	Link	GNSS
IGS Real Time Service (IGS RTS)	http://www.igs.org/rts/products	GPS, GPS+GLONASS
GNSS Data Center (GDC)	https://igs.bkg.bund.de/ntrip/orbits	GPS, GPS+GLONASS
MADOCA Real-Time Products	https://ssl.tksc.jaxa.jp/madoca/public/public_application_en.html	GPS+GLONASS+QZSS
CNES PPP-WIZARD	http://www.ppp-wizard.net/caster.html	GPS+GLONASS

IMPLEMENTATION OF PPP USING FREELY AVAILABLE SATELLITE BASED AUGMENTATION SYSTEMS (SBAS)

1. Heßelbarth A. SBAS orbit and satellite clock corrections for precise point positioning / A. Heßelbarth, L. Wanninger // GPS Solutions, 2012, vol. 17, issue 4, pp. 465–473. – DOI: 10.1007/s10291-012-0292-6. http://link.springer.com/10.1007/s10291-012-0292-6
2. Hyunho Rho Dual-frequency GPS Precise Point Positioning with WADGPS Corrections / Hyunho Rho, Richard B. Langley // NAVIGATION, Journal of The Institute of Navigation, 2007, vol. 54, issue 2, pp. 139–152.
3. Harima K. Performance of Real-Time Precise Point Positioning Using MADOCA-LEX Augmentation Messages / K. Harima, S. Choy, Y. LI, T. Grinter. // Proceedings of FIG Congress, 2014, pp. 16–21. http://www.fig.net/resources/proceedings/fig_proceedings/fig2014/papers/ts03b/TS03B_choy_li_et_al_6906.pdf
4. Vitaly Sernov GNSS GLONASS Augmentation System SDCM. Status and development //United Nations/Russian Federation Workshop on the Applications of Global Navigation Satellite Systems – 2015. http://www.unoosa.org/documents/pdf/psa/activities/2015/RussiaGNSS/Presentations/6.pdf

CONCLUSION

Already in place
Free software for precise positioning.
Free post-processing online services.
Free real-time access to GNSS ephemerides and clock corrections.

Anticipate soon
Data for real-time PPP via freely available SBAS (QZSS, WAAS, SDCM).
Also dramatic decrease of cost for dual-frequency GNSS equipment is probable.

Prospect
In future positioning at sub-decimeter level of accuracy may become available to the vast majority of GNSS users which will significantly change surveying as a profession.

CONCLUSION

Some Urgent Tasks

- Development of toolchains based on free software for geodesy and mapping.
- Development of free software for specific applications to fulfill gaps in the toolchains.
- Automatization of survey data processing by developing online processing services.
- Improvement of data processing algorithms to handle effects specific to low-cost equipment.
- Implementation of PPP by means of SBAS.
- Solving a problem of technical regulation and adoption of online processing services, free software and low-cost hardware for high-precision positioning in the countries where certification of such instruments is mandatory.

FIG WORKING GROUP 5.6
"COST EFFECTIVE POSITIONING"

Policy issues

- Educate FIG member associations and individual surveyors on when to use which surveying instrument and data processing software taking into account economic reasons
- Design fit-for-purpose surveying systems that are cost-effective
- Support decision makers for establishing cost-effective positioning solutions

Specific project

Developing guidelines for cost-effective use and design of survey solutions including costs for labor and investment

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FIG

Thank you for attention!

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