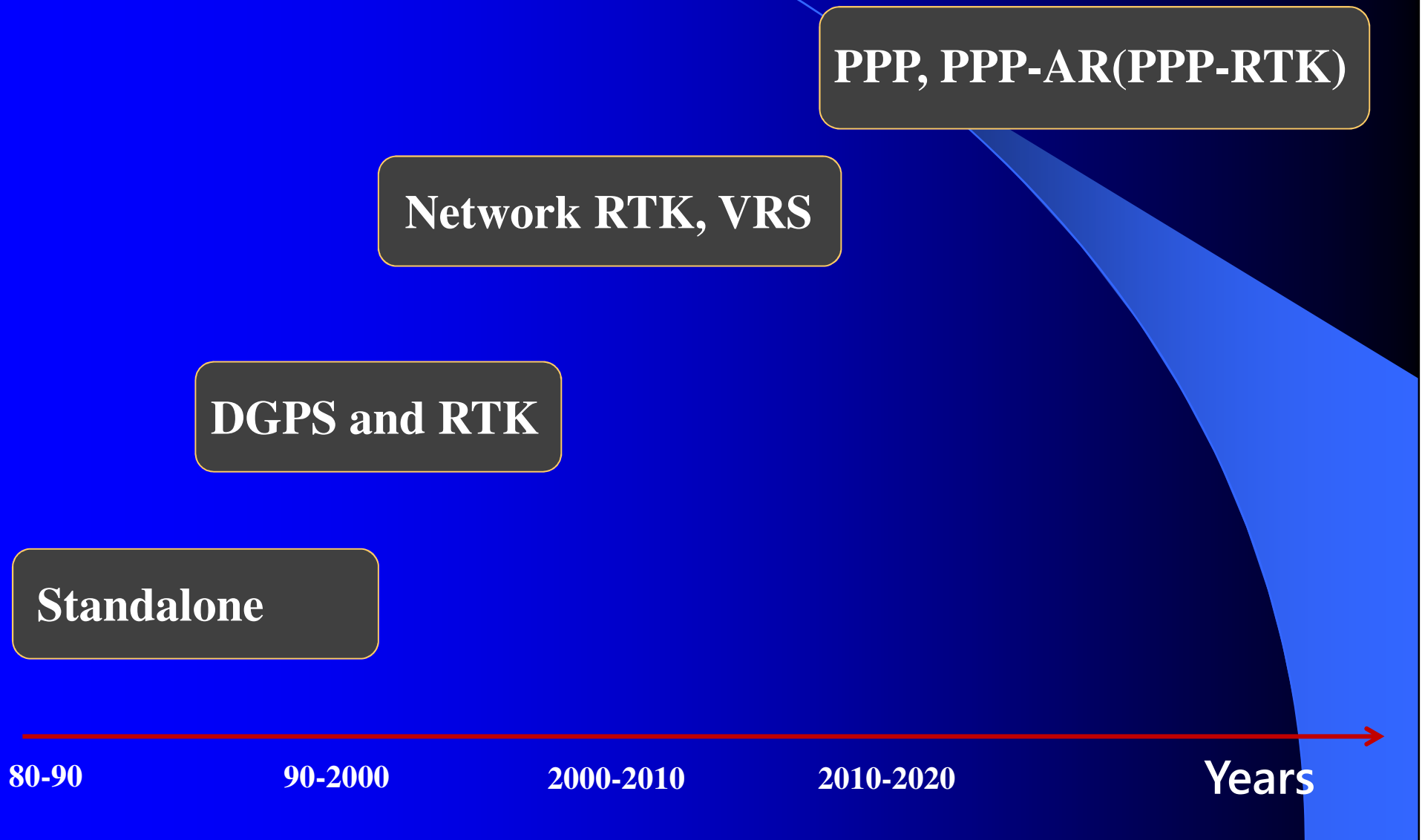# GNSS Accuracy Improvements through Multipath Mitigation with New Signals and services

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10 Meeting of the International Committee on Global Navigation Satellite Systems (ICG-10)
November 2015, Boulder

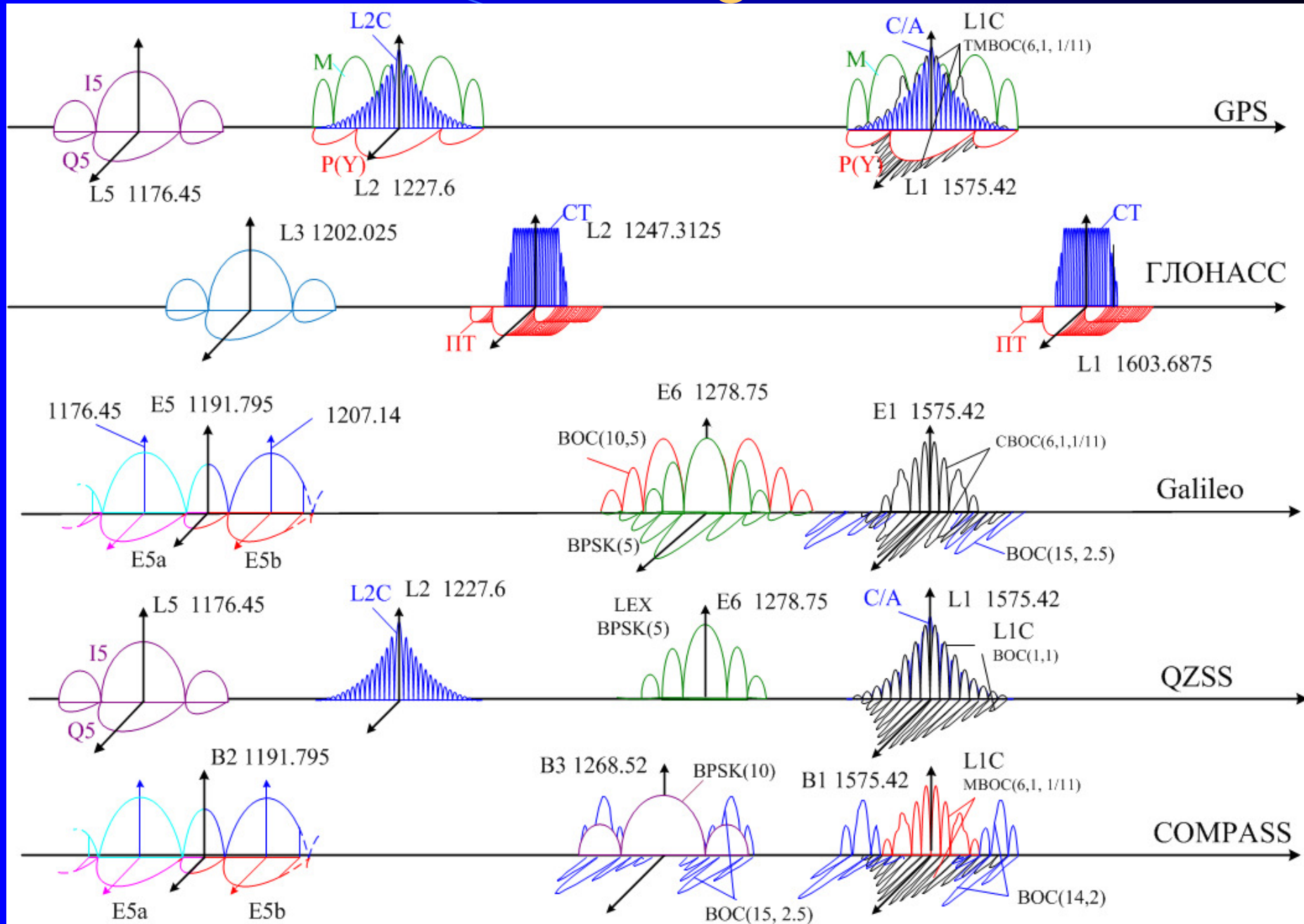# Evolutions of positioning methods with GNSS signals

PPP, PPP-AR(PPP-RTK)

Network RTK, VRS

DGPS and RTK

Standalone

80-90   90-2000   2000-2010   2010-2020   Years

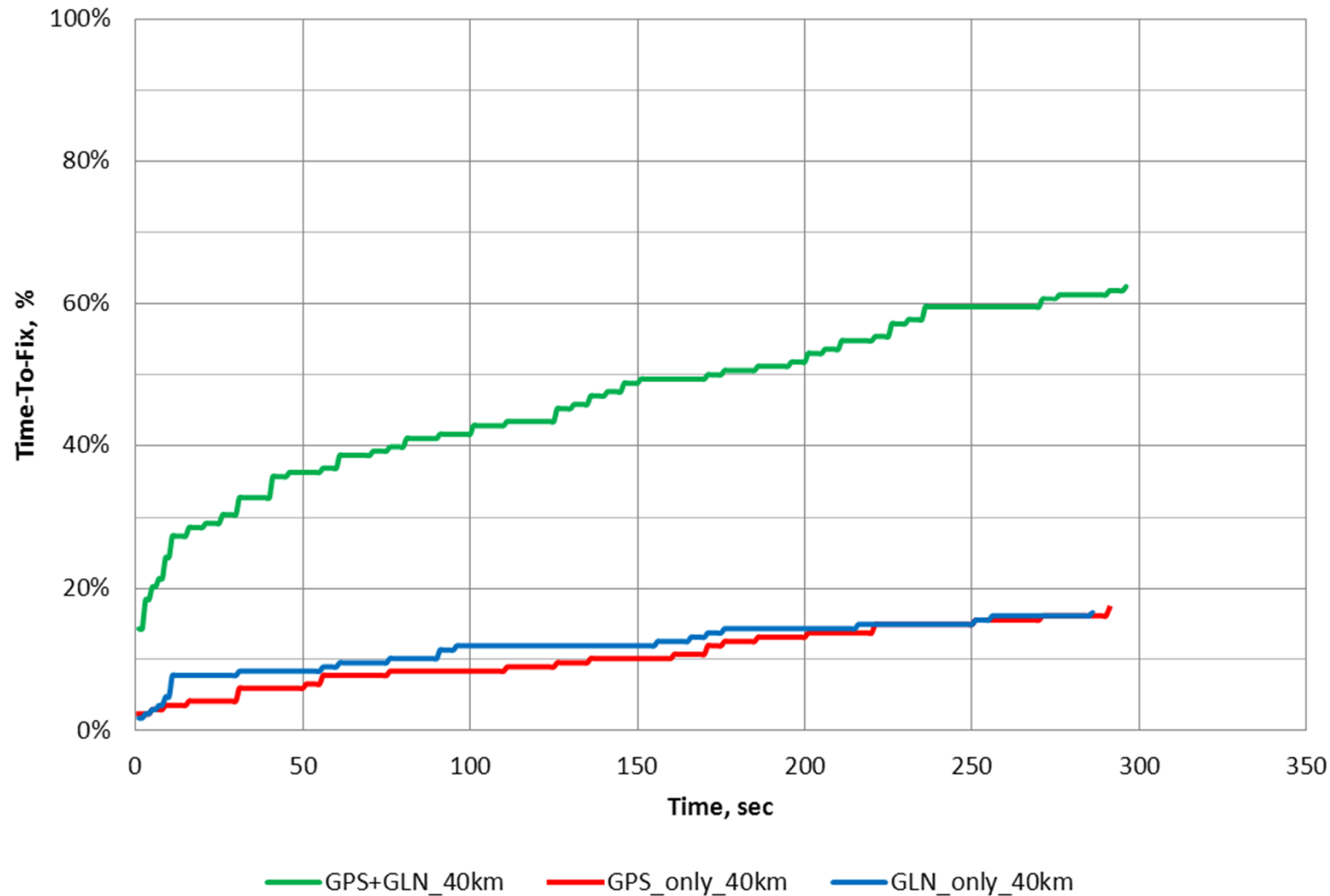# Positioning with multi-system GNSS receivers

- - GIS;

    DGPS, RTK

- - Geodesy;

    RTK

- - Machine control application;

    RTK

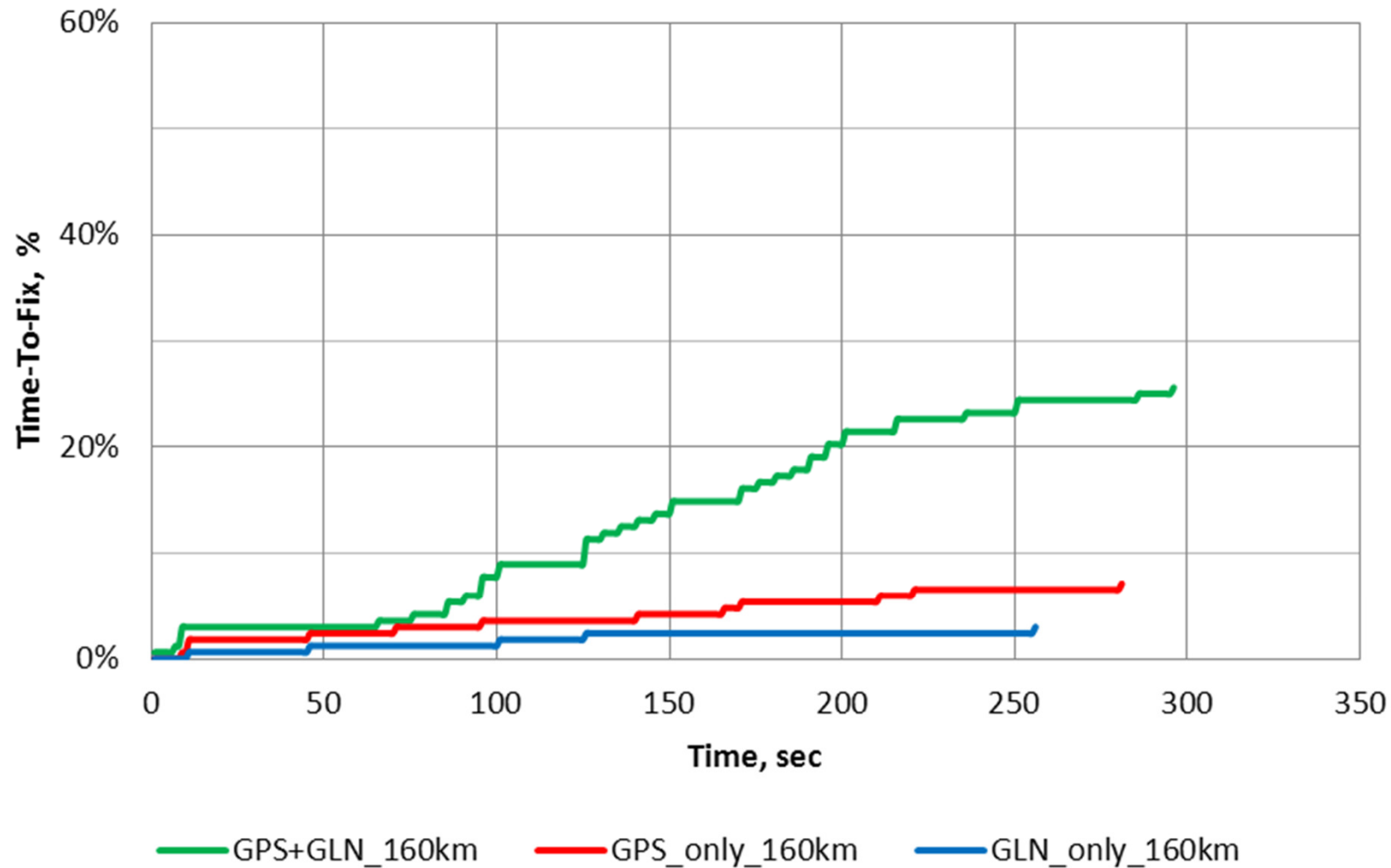- - Automatic Agricultural systems

    StandAlone, DGPS, RTK

GNSS signals

Time to fix for ambiguities resolution of RTK for medium range base line

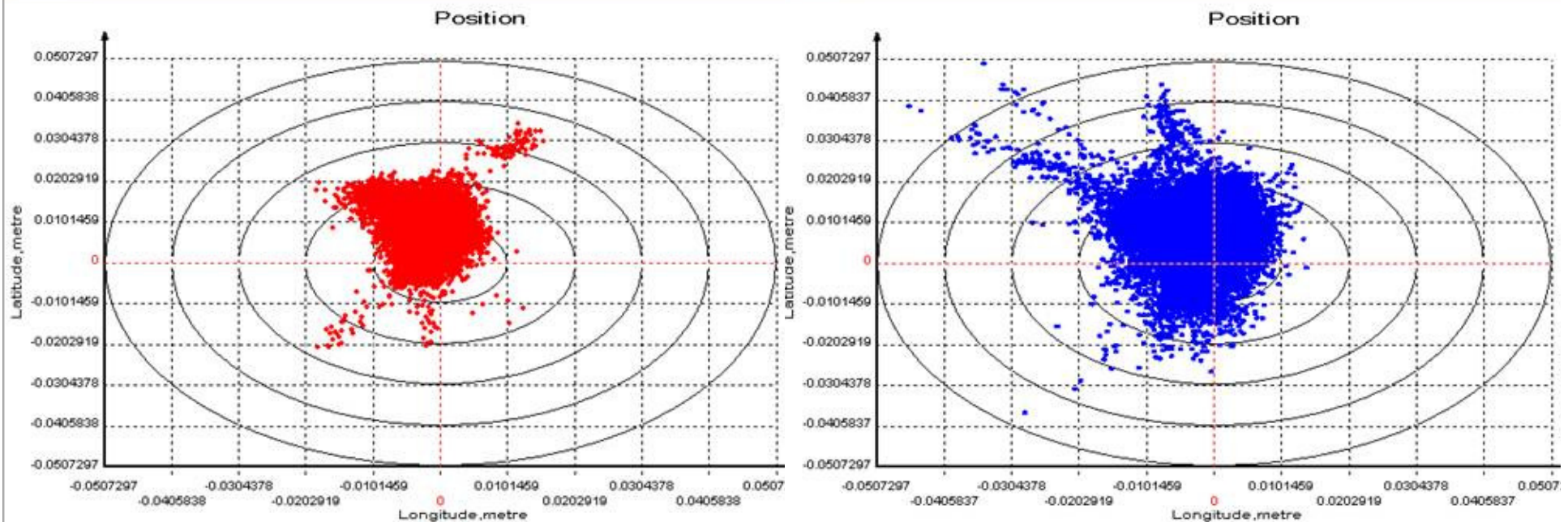# Time to fix for ambiguities resolution of RTK for long range base line

Static GPS/GLONASS RTK performances

RTK GPS-only solution:

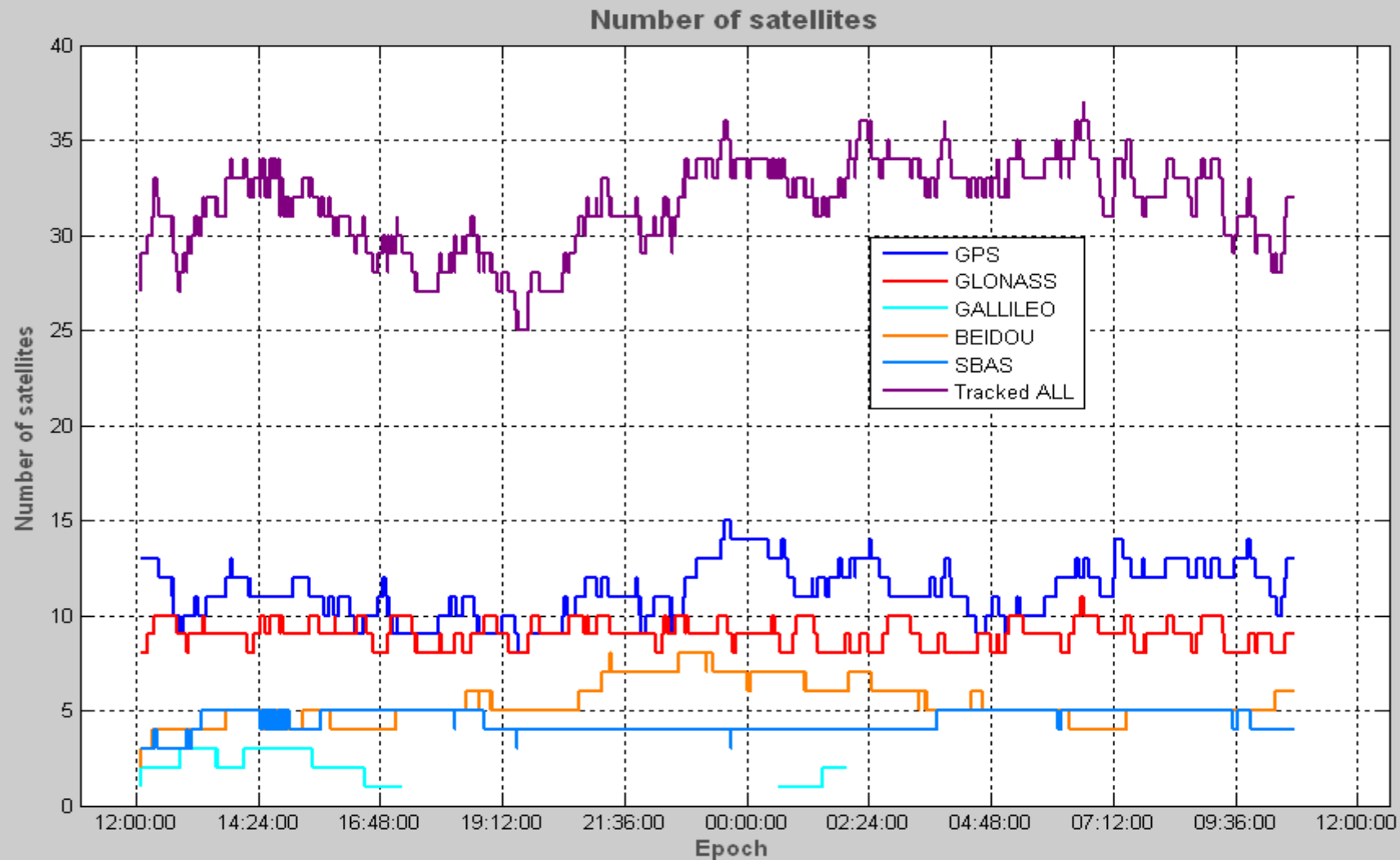At all epochs (GPS SVs: $6 \leq SV \leq 12$)

RTK GLONASS-only solution:

At a subset of all epochs when total number of GLONASS SVs ≥ 7

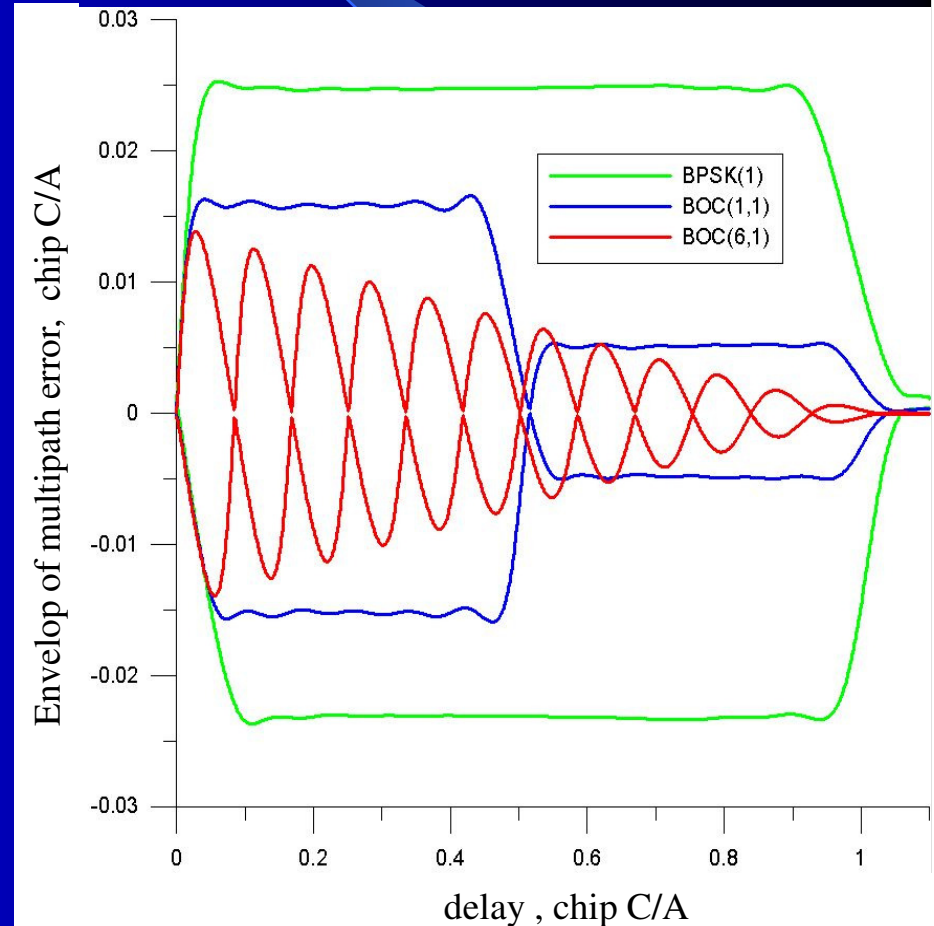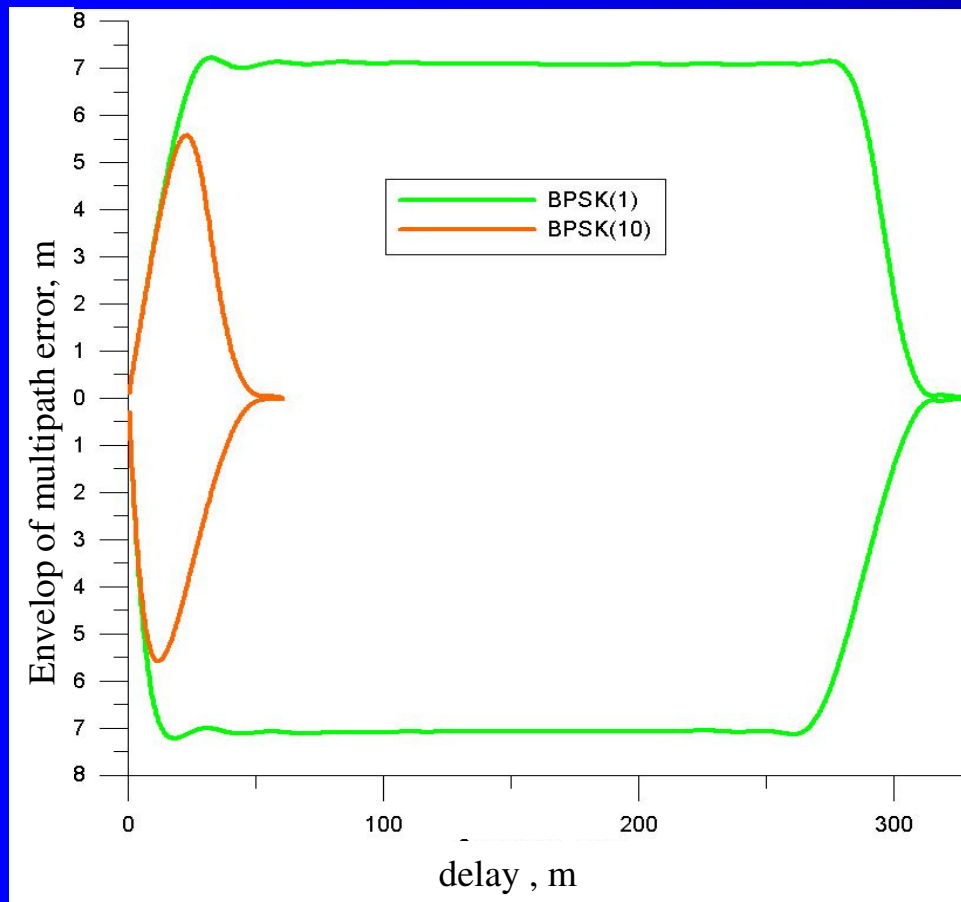Accuracy of GLONASS RTK positioning is the same as GPS RTK accuracy

Tracking example, Number of satellites – GPS/GLONASS/GALILEO/COMPASS/SBASS
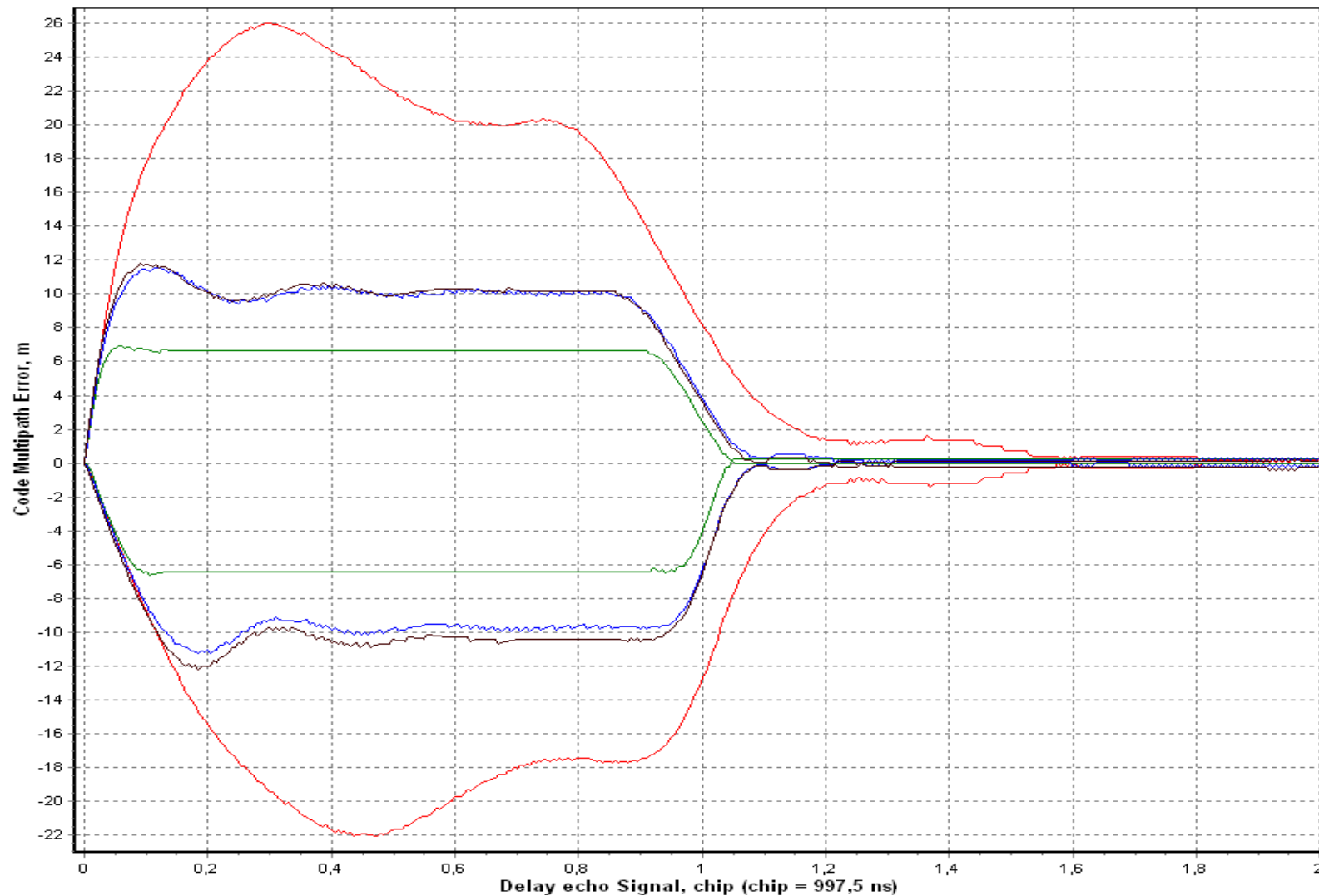
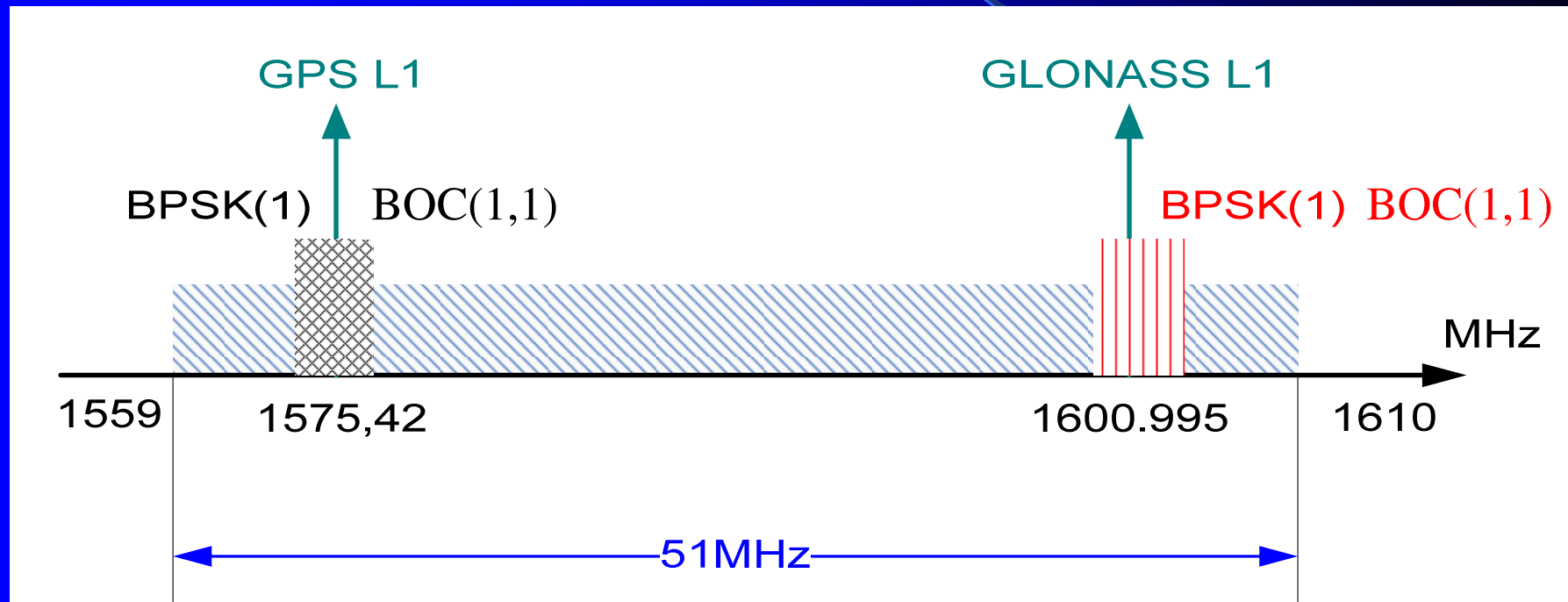# Multipath error for different GNSS signals

Multipath envelops for reflection signal with amplitude of 0.5
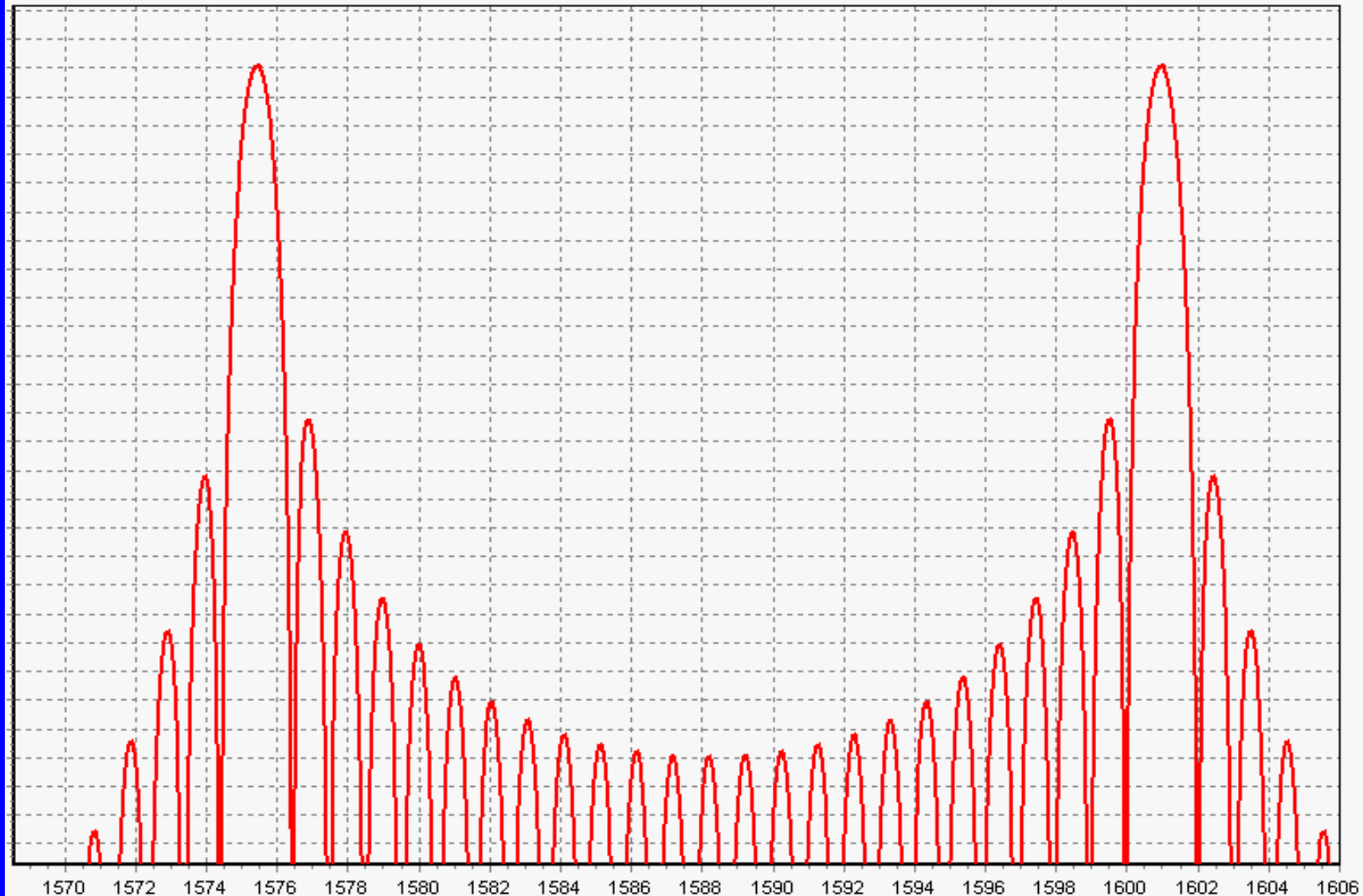
Multipath error for different navigation receivers technology

GNSS signals for L1 frequency band

Spectrum in L1 frequency band
(GPS/GALILEO L1 and GLONASS L1)

Multipath error for wideband signal in L1 frequency band

Multipath error for DBOC signal
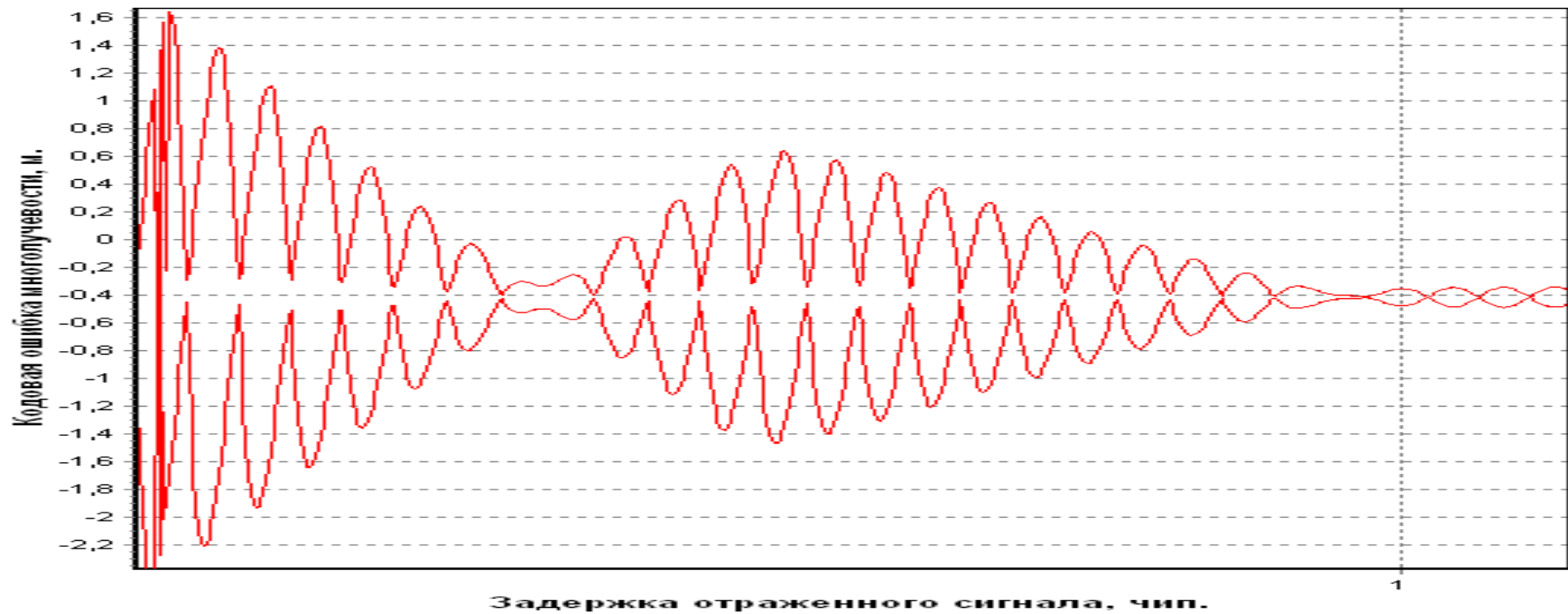
Signal	Maximum code multipath error, m.	
C/A BPSK(1)	7,284	
BOC(1,1)	3,86	
BOC(10, 5)	2,8	
DBOC	*2,341*	

GNSS signals in frequency band of GPS L5, GALILEO E5, GLONASS L3
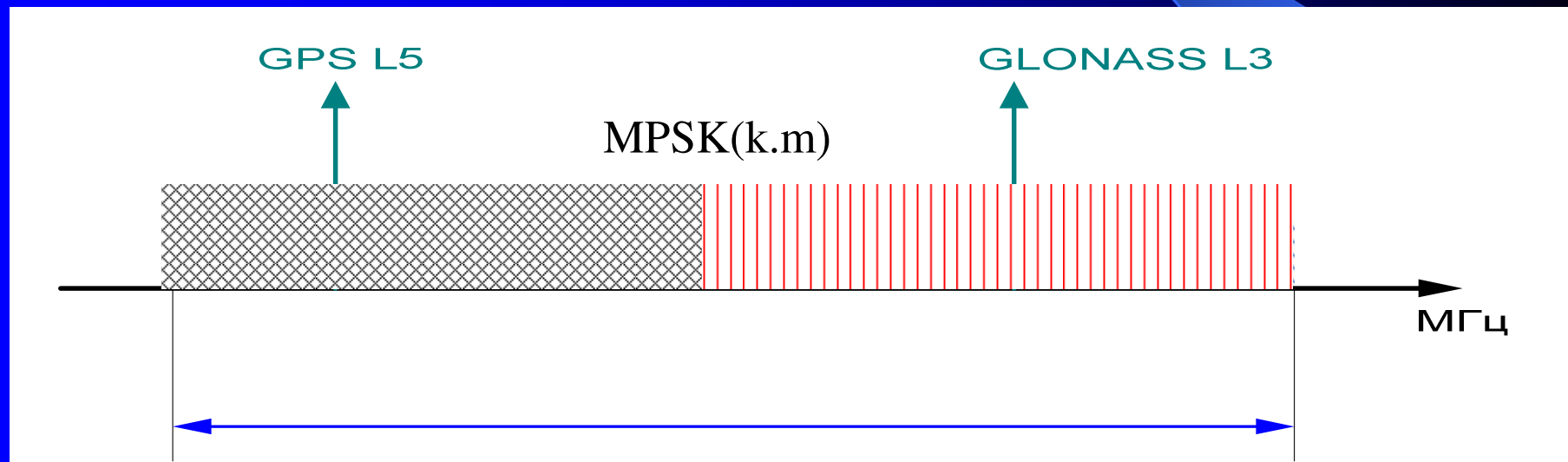
Multipath error wideband signal in E5 (L5/L3) frequency band
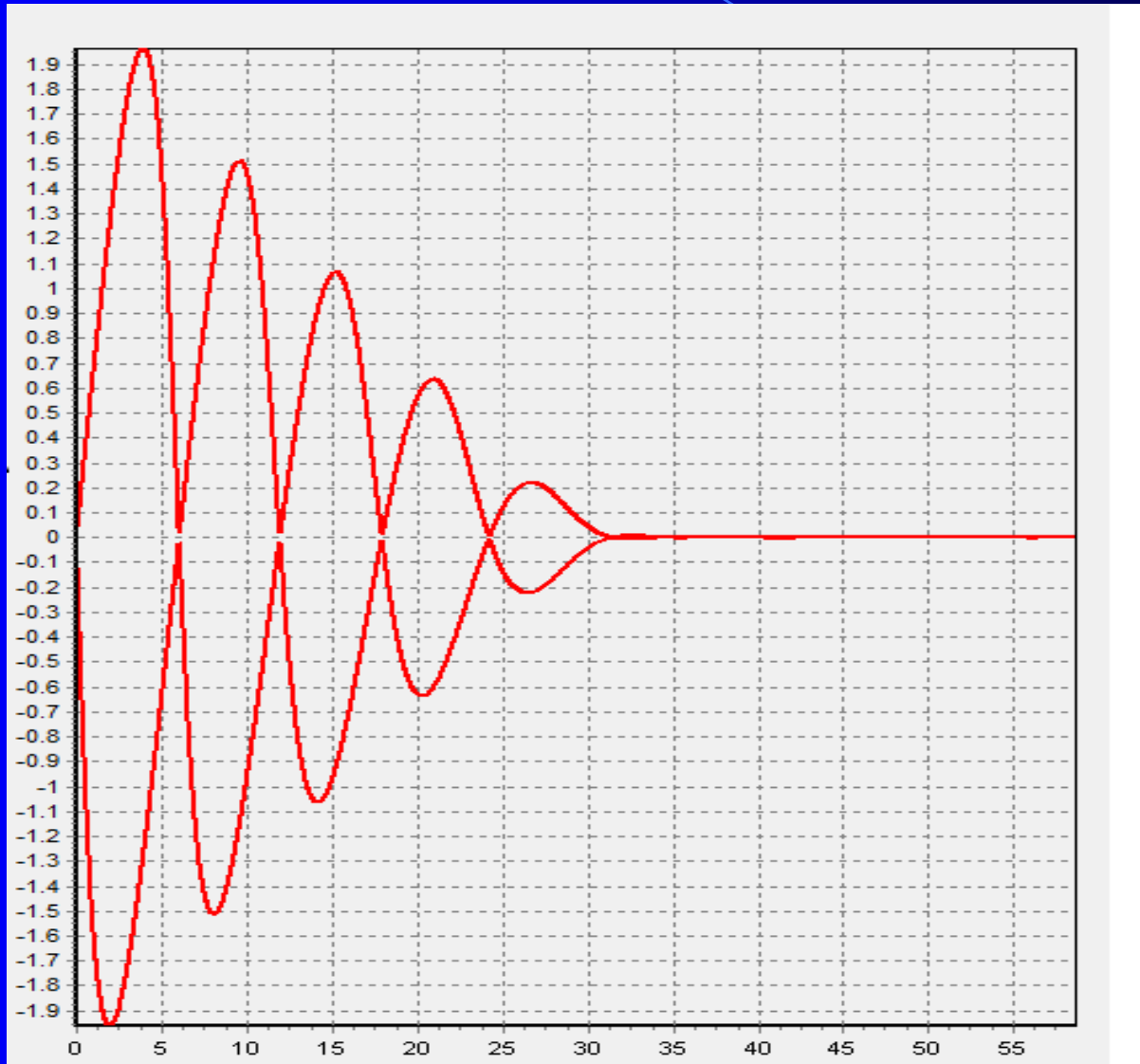
Precise Point Position

- Current PPP service
  - StarFire
  - OmniSTAR
  - TerraStar
  - IGS-RT
- Calculation of precise orbit and clocks
  - Base stations network
  - Calculation of satellite parameters
  - Real-time corrections
- User Positioning
  - Accuracy
  - Convergence time

Precise point positioning with precise orbit and clocks from different IGS analytic centres

IGS

after 30 min. accuracy ~40mm

IAC

after 30 min. accuracy ~50mm
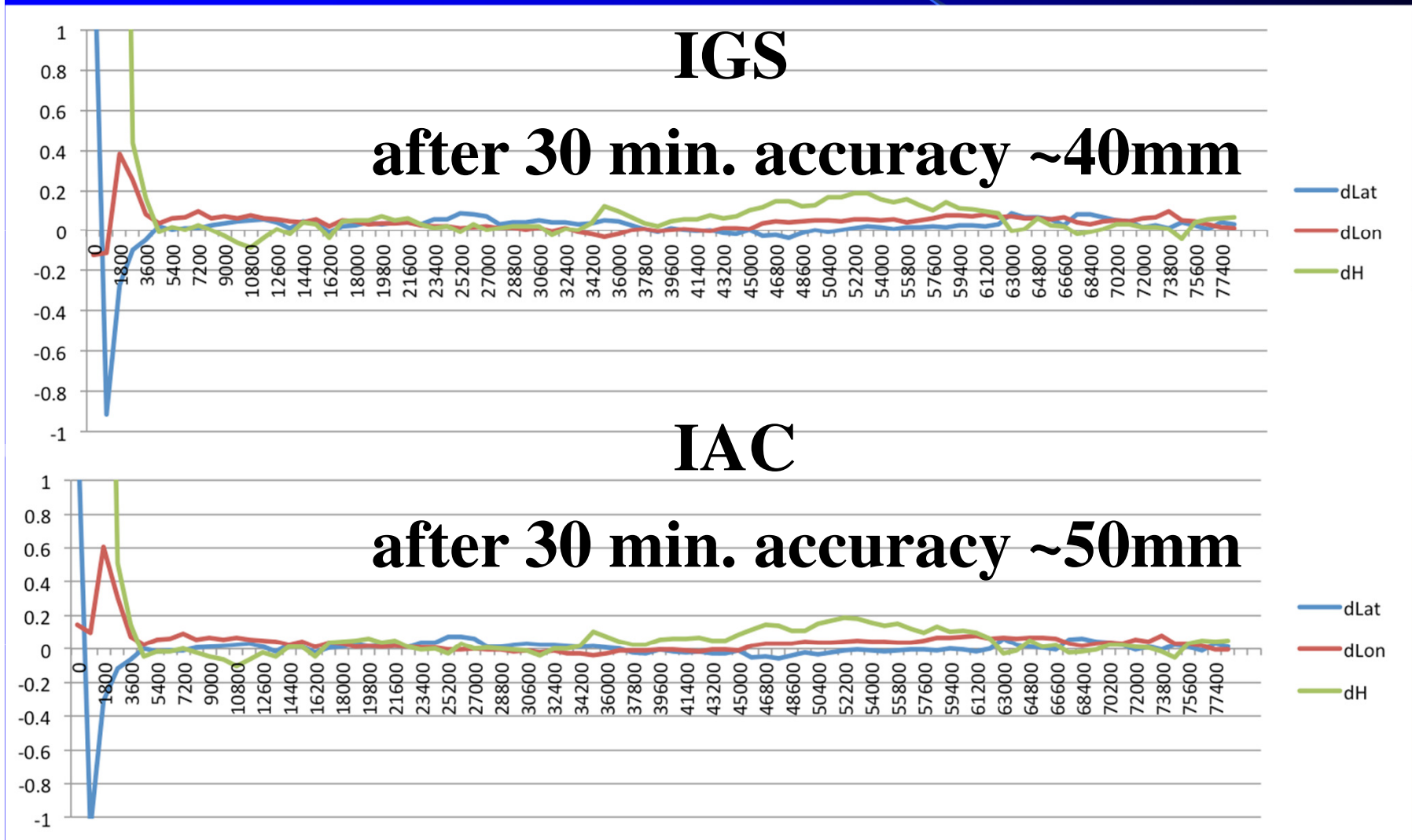
PPP with GPS, GLONASS and GPS+GLONASS

Used Final Precise Orbits and clocks from Analytic center IGS.
Period of correction – **30 seconds**;

Estimation of RMS solution after **20 minutes** - period of convergence.

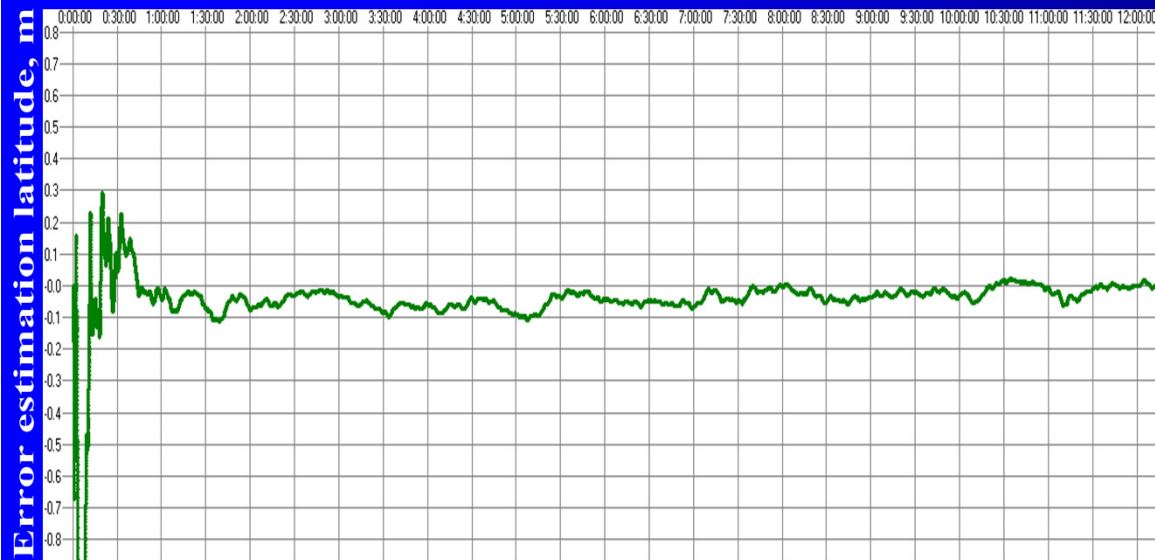|	RMS, m			
	Latitude	Longitute	Vertical	2DRMS
GPS+GLONASS	0.005	0.018	0.019	0.019

Regional PPP service: QZSS LEX signal

- **-** Time multiplexing Long and Short Codes

- - Chip rate 5.115 MHz

- - The 4ms Short Code modulated by navigation

    information by using code shift keying

- - 256 code shift position is used

- - 2000 Bits/s data stream Reed-Solomon encoded

- - The Long Code with length 410ms modulated by
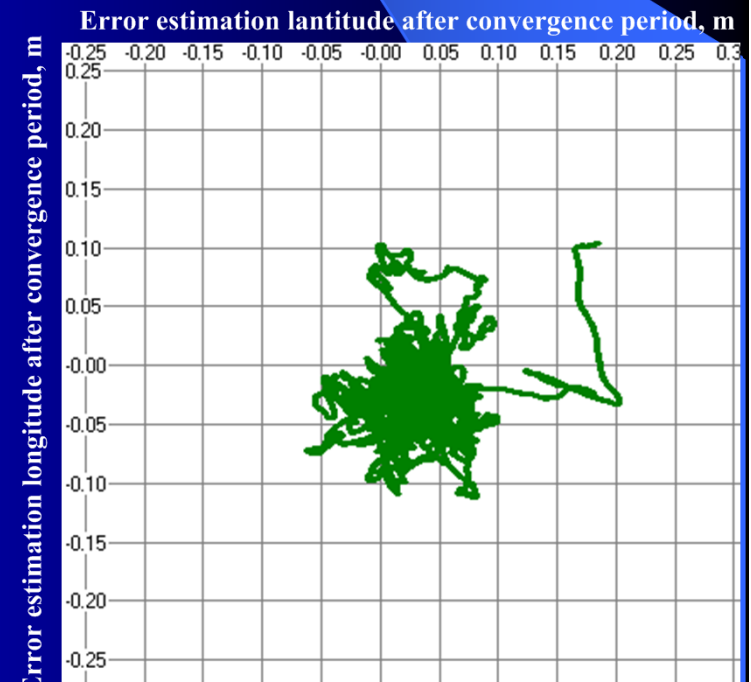
square wave with period 820 ms

Precise Point Positioning with Precise corrections from JAXA

- Precise ephemerides Data from JAXA SP3 final archive. Period of correction data – **300 seconds**.
- Only GPS Constellation
- Map View is presented below and estimated RMS solution after period of convergence – **30 minutes**.

	RMS, m			
	Latitude	Longitude	Vertical	2DRMS
GPS	0.044	0.043	0.07	0.063

Error estimation latitude, m

Time hours:minutes:seconds

Error estimation lantitude after convergence period, m

Error estimation longitude after convergence period, m
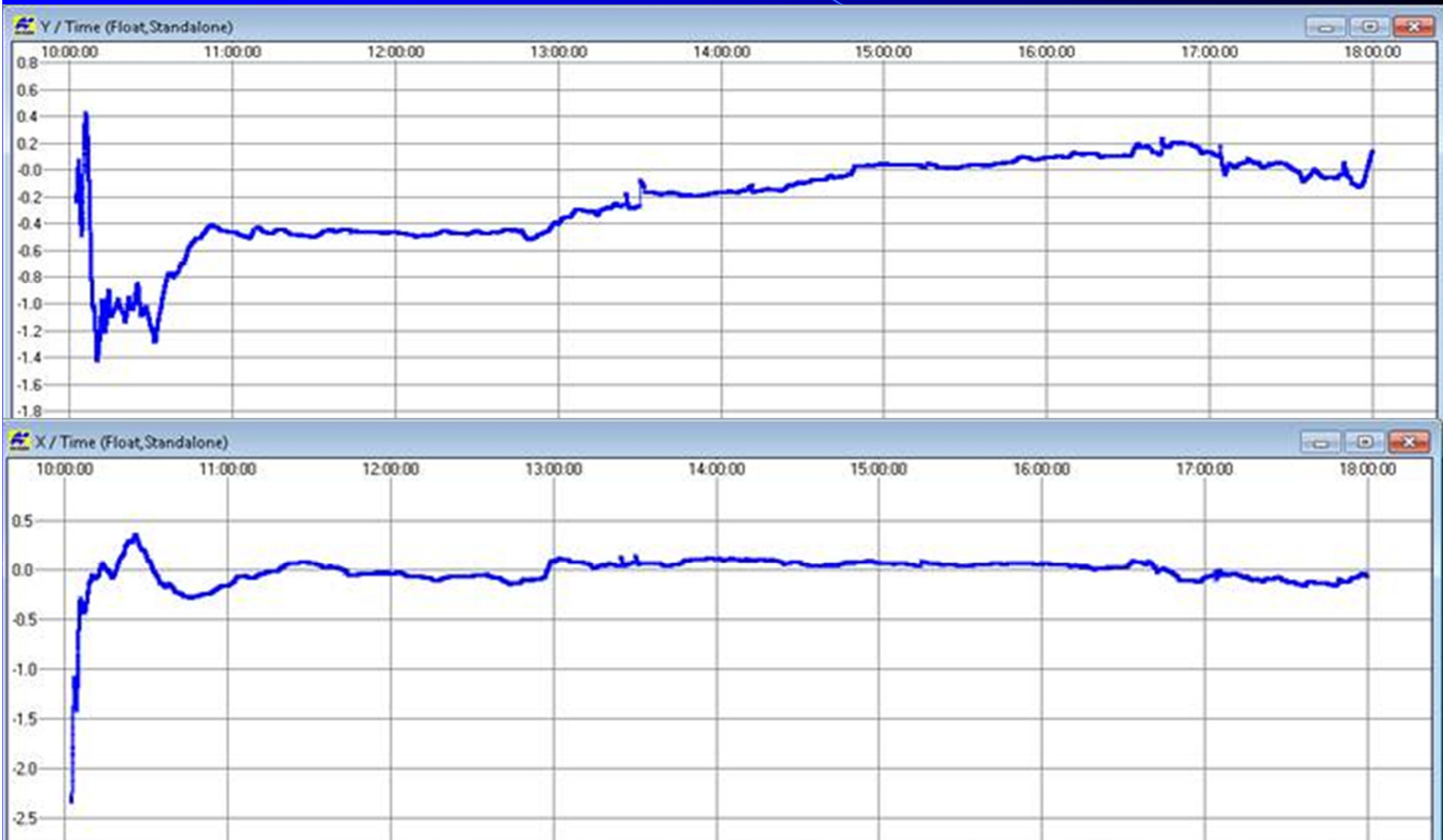
MADOCA-LEX Precise Point Positioning

- RTCM correction from QZSS, messages 1057, 1059,1061,1062,1063,1065,1067,1068
- Low elevation in test site

GNSS Signals with precise orbit and clock correction

Information about precise orbit and clocks requires fast update rate and can be useful for global region

The QZSS transmitted precise orbit and clocks in MADOCA-LEX signal. GALILEO is planning to use E6 for commercial service.

Recommendation: PPP corrections from all GNSS providers should have free user access.

Possibility of interoperability of these services.

Summary

1. Possibility of global transmitting of precise orbit and clock corrections at high rate will improve accuracy of positioning with PPP methods in receivers.

2. Common wide band signal for all GNSS in E5 band (E5a/L5 + E5b/L3 band) and L1 band will minimize multipath error and improve time-to-fix for high precision applications and will be compatible with low-cost receiver when signals in half wide band are used.

Thank you for attention!