



*High precision agriculture and machine control
with GLONASS, GPS and other GNSS systems*

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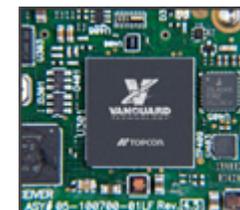
9th Meeting of the International Committee on Global Navigation
Satellite Systems (ICG)
November 2014, Prague

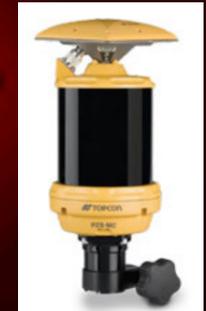
Topcon Positioning Systems is a leading designer and manufacturer of high precision GNSS instruments, imaging systems, automation systems, and workflow solutions for the global construction, survey and agricultural industries. Topcon offers advanced solutions designed to meet escalating information modeling, infrastructure and resource needs of the world.



Full Spectrum GNSS Technology Provider

- In-house development of all core GNSS technology
- Multi-constellation ASIC development
4th generation multi-core designs are currently in production
- Precision mobile and infrastructure antennas
- Full range of OEM and application-specific receivers that cover all GNSS frequencies
- Leading-edge tracking, navigation, fusion, and network algorithm development





*AGI-3 Receiver
GX-45 Console*



All GNSS receivers as minimum support GPS and GLONASS systems



Two systems (GPS and GLONASS), two frequencies, GNSS boards with digital processing in ASIC



GNSS boards with system-on-chip in ASIC



Multi-system (GPS/GLONASS/GALILEO/COMPASS/QZSS), multi-frequency GNSS boards with system-in-package in ASIC

Area of High Precision GNSS Application **Land Leveling**



Example of Land Levelling Operation

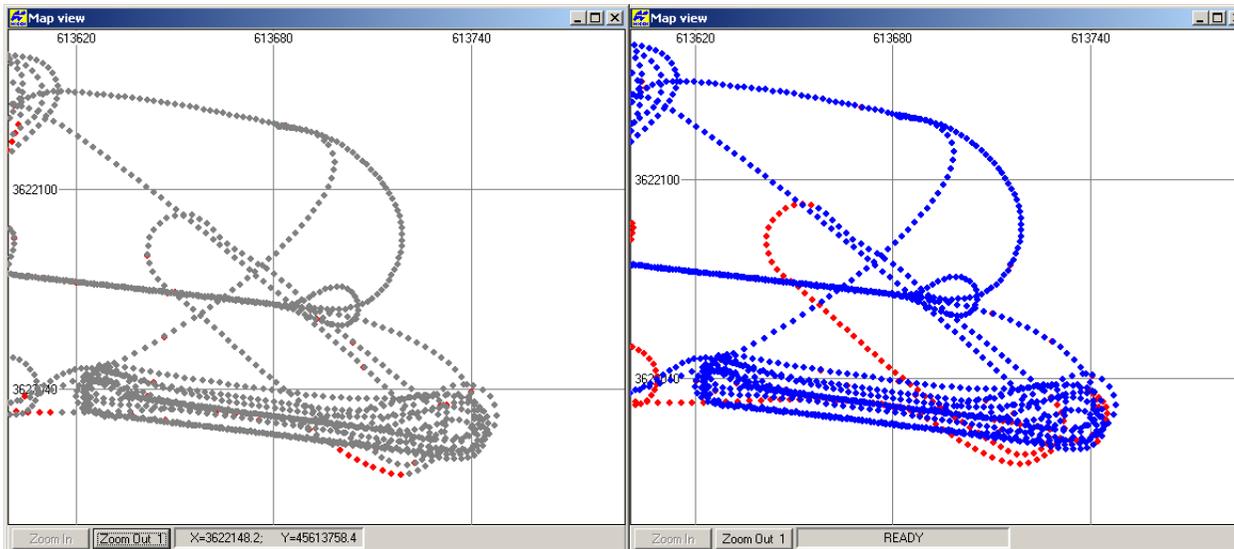


Vertical accuracy shall be better than 3 cm

Multi GNSS. Land Leveling



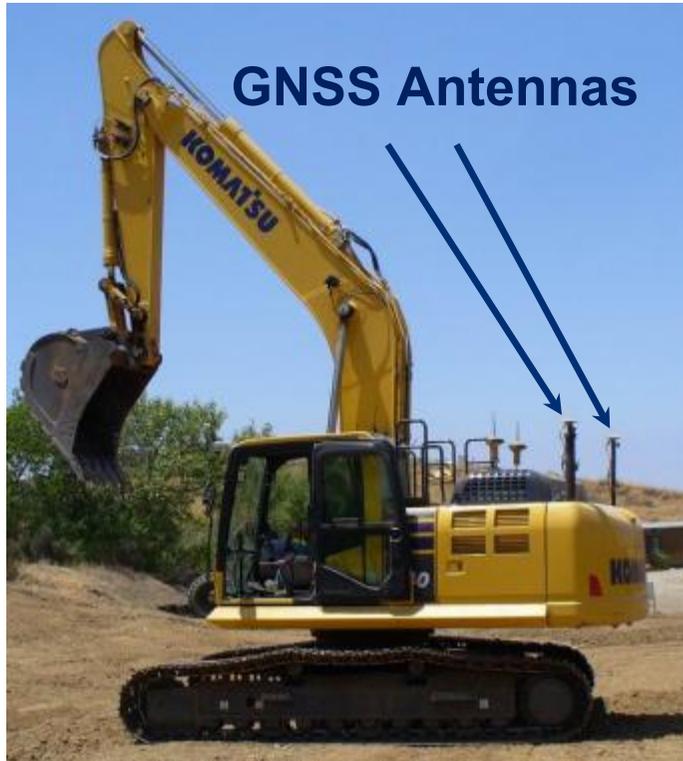
- Land leveling is high precision application
- Vertical accuracy better than 3 cm
- RTK (GPS + GLO)
- Operation near trees – challenging area
- GPS+GLO provides best results
- When close to trees, only GPS+GLONASS provide reliable high accuracy positioning required for land leveling



	% FIX
GPS-only	92 %
GLO-only	87 %
GPS+GLO	98 %

■	GPS+GLONASS
■	GPS Only
■	GLONASS Only

Area of High Precision GNSS Application **Controlling Excavator**



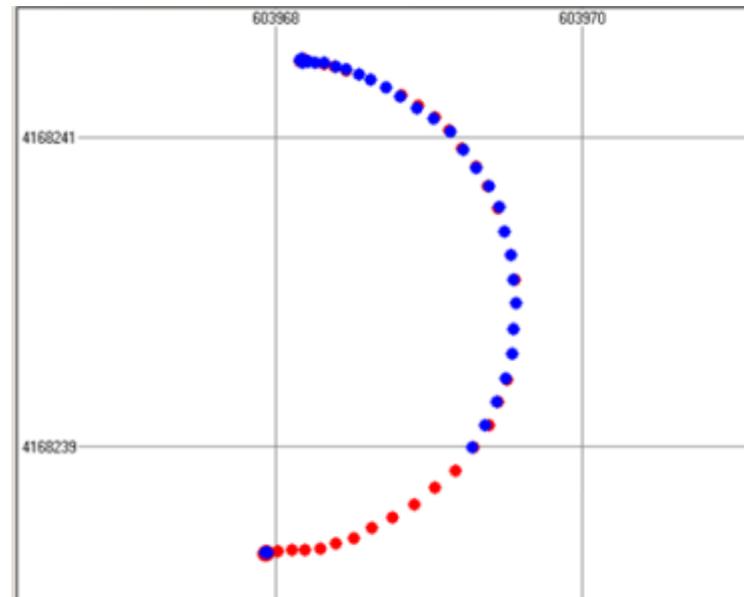
Horizontal accuracy shall be better than 6 cm

Multi GNSS. Excavator



GNSS antennas are shaded by boom

- Excavator control w/ RTK
- High precision application
- Horizontal accuracy better than 6 cm
- Challenge: maintain FIX while rotating with boom up
- GPS+GLO provides best results



■ - GPS+GLO
■ - GPS Only

	% FIX
GPS-only	73 %
GLO-only	68 %
GPS+GLO	99 %

Test rail-way for dynamic tests and collection statistics for agricultural and machine control application



	% FIX
GPS-only	99.85 %
GLO-only	96.24 %
GPS+GLO	100.0 %

- Rail way test track, Italy. Loop by loop 12 hours tests RTK (GPS + GLO)
- Light shading by two metallic constructions

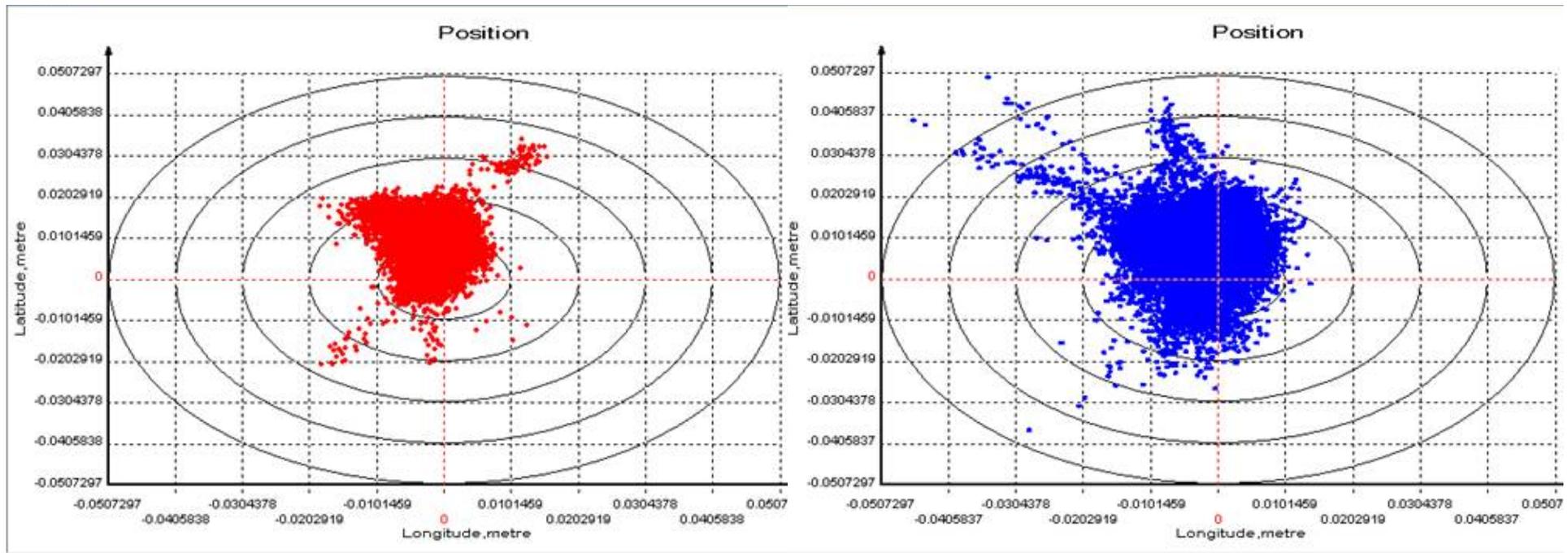
STATIC GPS/GLONASS RTK positioning performances

RTK GPS-only solution:

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

RTK GLONASS-only solution:

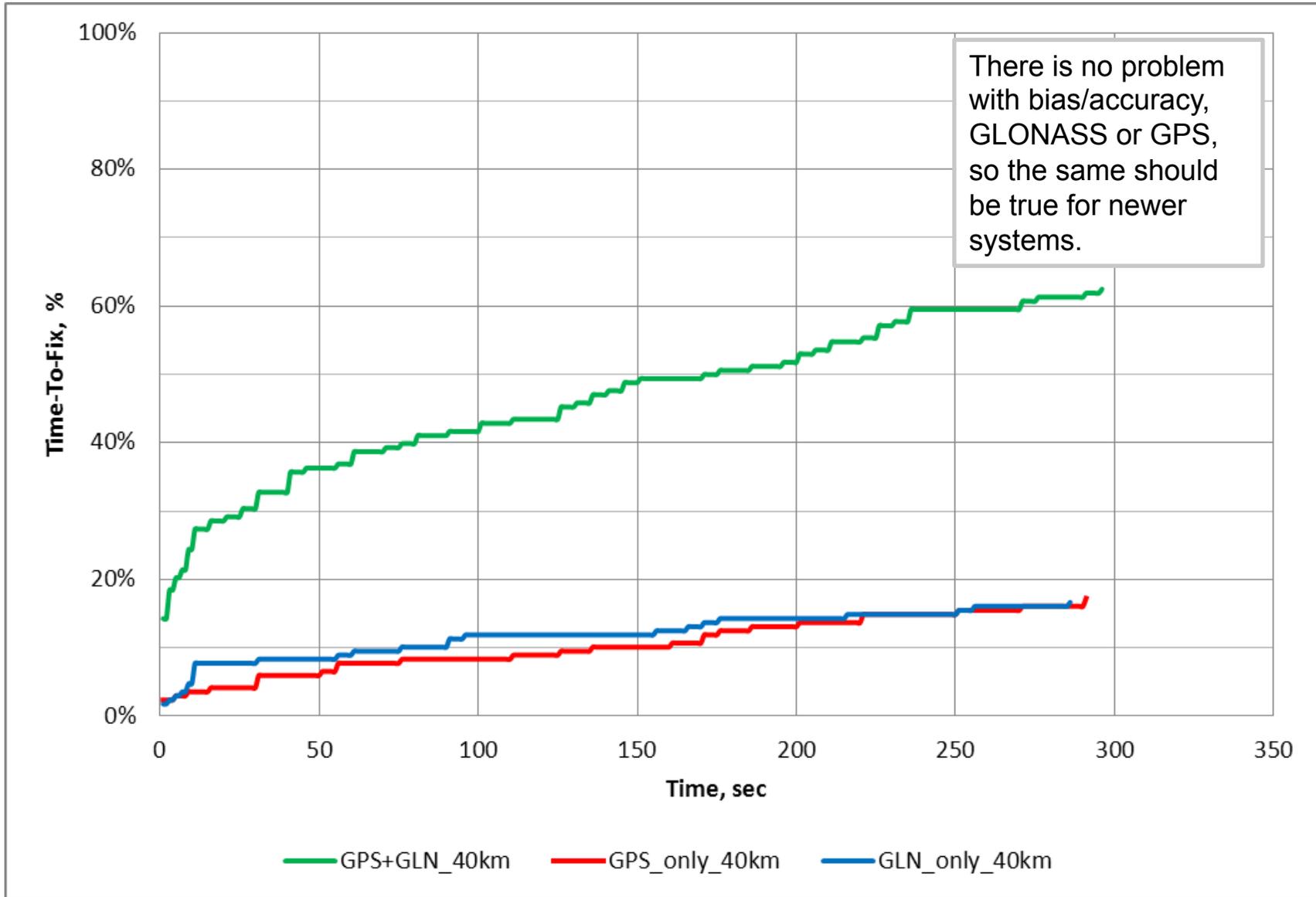
At a subset of all epochs when total number of GLONASS SVs ≥ 7



Accuracy of GLONASS RTK positioning is the same as GPS RTK accuracy provided enough number of GLONASS satellites are available for positioning

Example of Probability

Time-to-Fix of ambiguities for medium baseline (40km) RTK

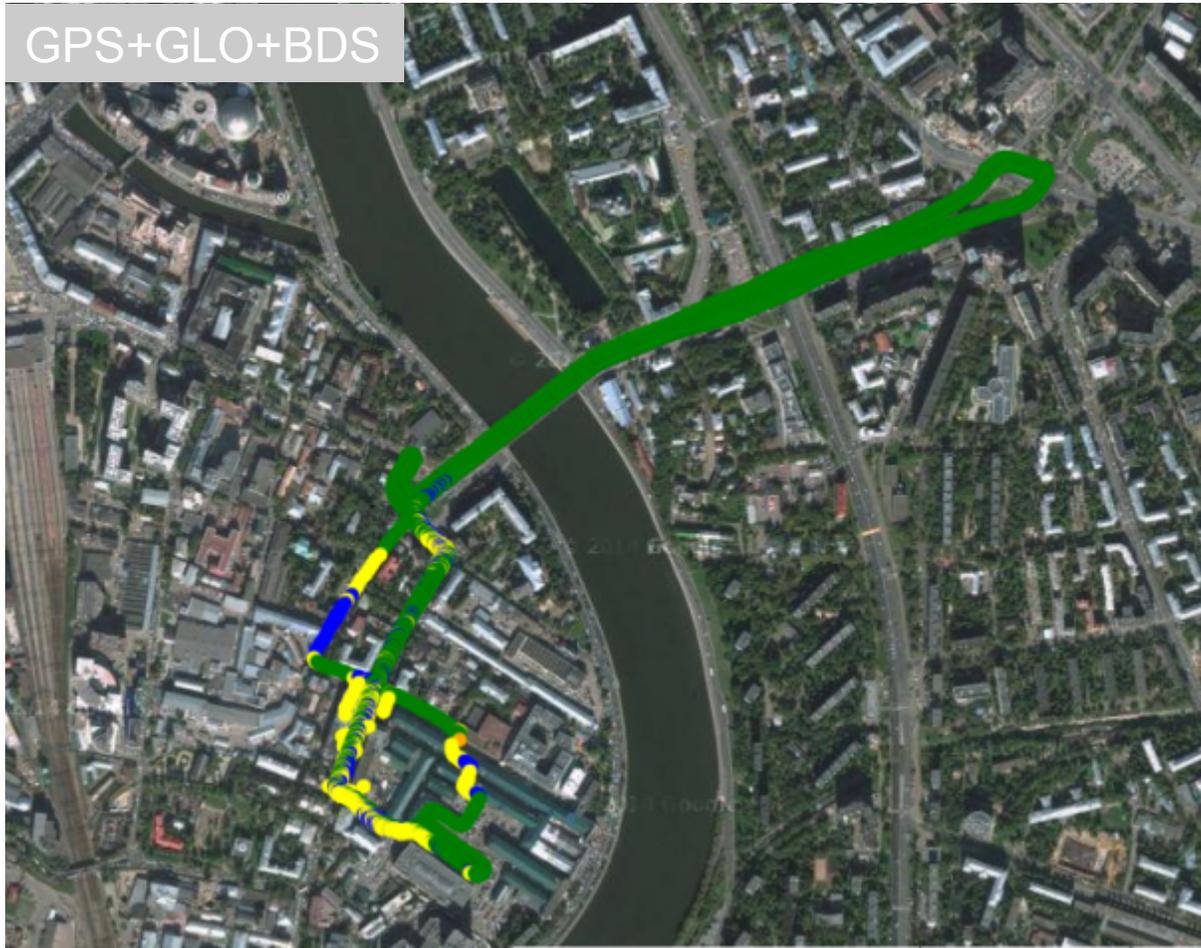


Multi GNSS in obstructed areas

- Shaded environment (Urban canyons in Moscow)
- RTK (GPS, GLO, BDS)
- The more GNSS SV available the higher number of FIX positions available in shaded environment

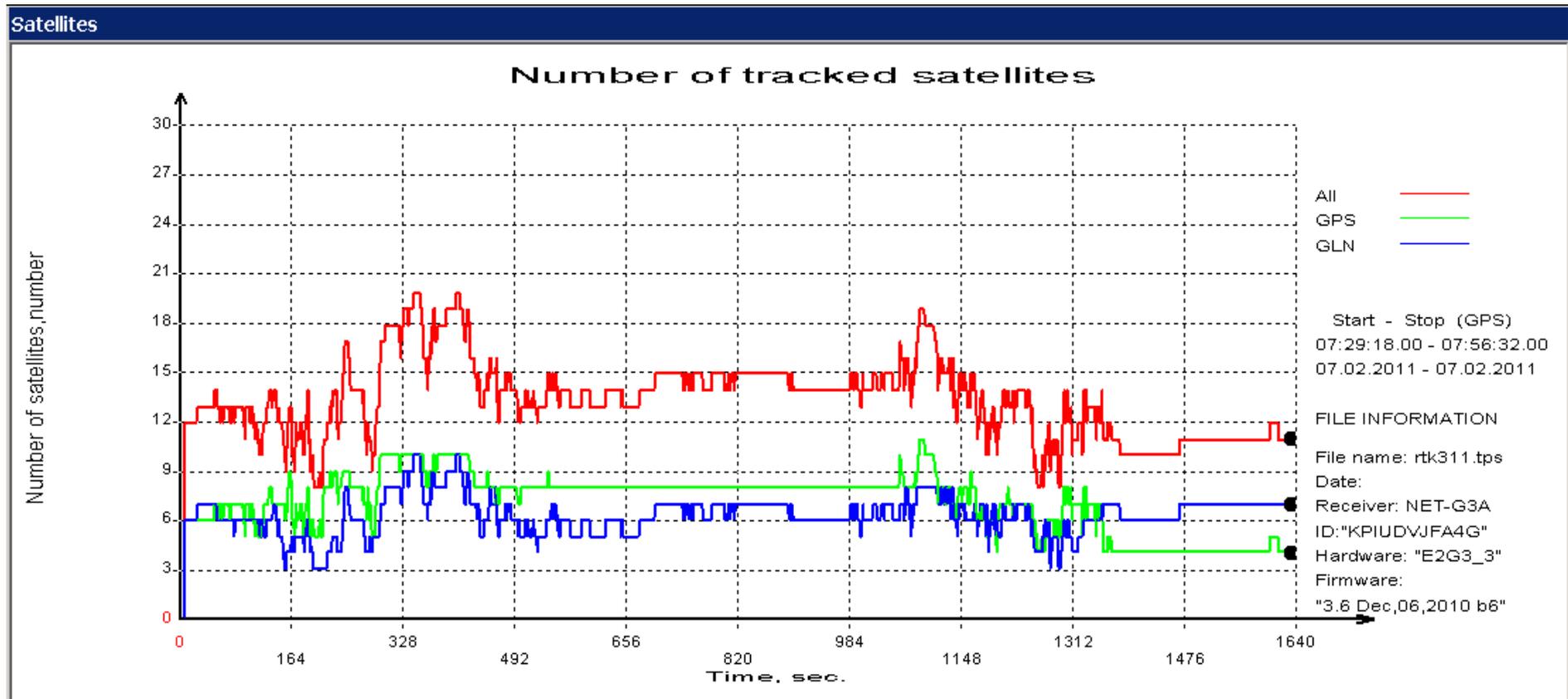
	% FIX
GPS-only	53.3 %
GLO-only	39.6 %
GPS+GLO	92.4 %
GPS+GLO+BDS	93.2 %

GPS+GLO+BDS



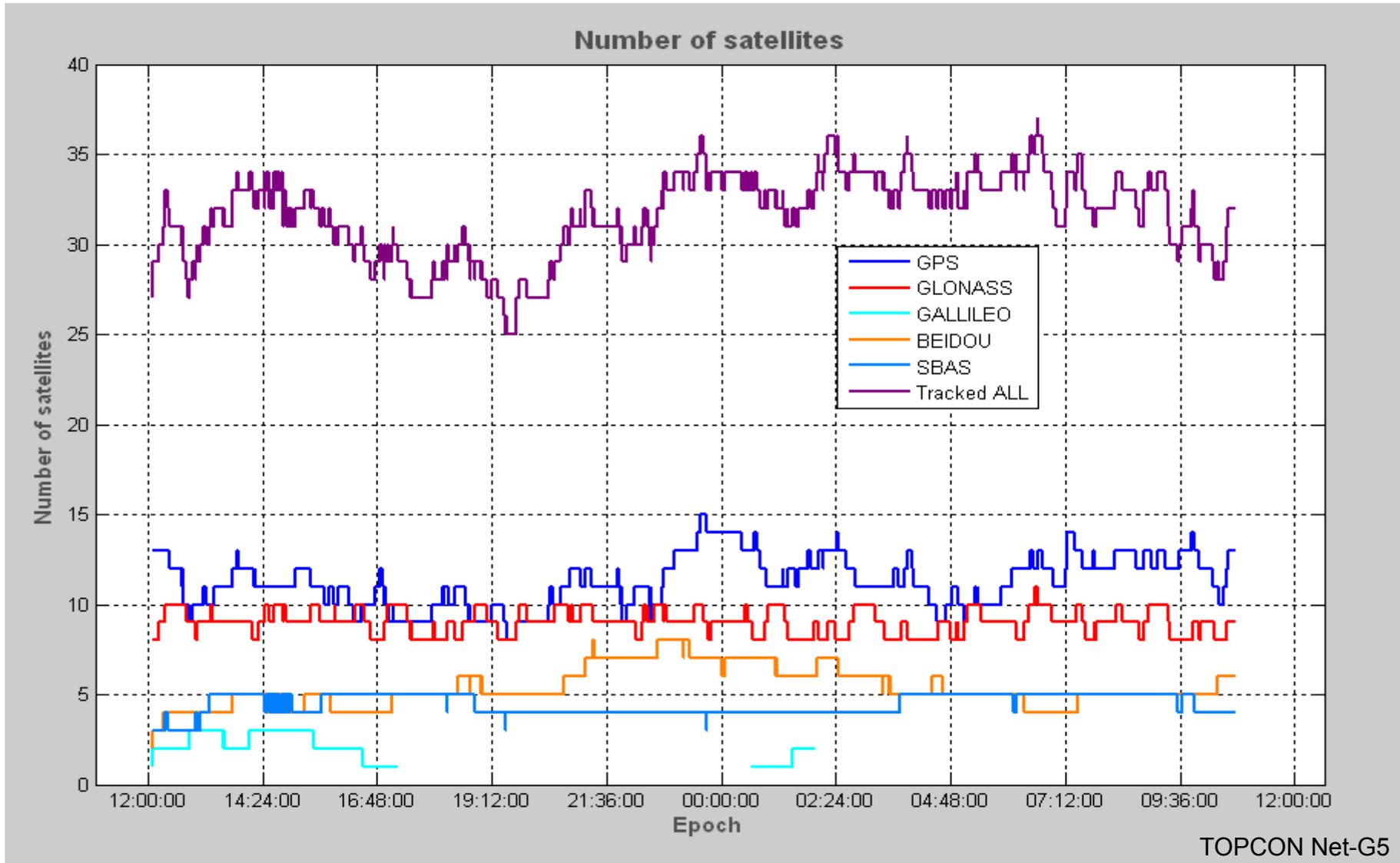
- NO_SOLUTION
- Standalone
- Code_DIFF
- RTK Float
- RTK Fix

Satellites of GPS/GLONASS enough?



Same Urban Canyon, Moscow

Measured number of Satellites available today GPS/GLONASS/ GALILEO/COMPASS/SBAS



Technology Perspective

- Multi-frequency positioning
 - GNSS will lead towards instant RTK fix due to new signals (multi-constellation, multi-frequency) and to ubiquitous RTK or PPP correction services (satellite-based, land-based, etc.)
- From Networks to Global Services
 - High-accuracy global services with precise orbits and clocks from GNSS providers (for example QZSS Lex extended globally)
- Availability of more Local Satellite Correction Services (QZSS, GAGAN,..)
- Technology: High-Precision Multi Frequency Receiver in a smaller footprint
- New challenges for GNSS providers
 - Reliability and availability of service
 - Ability to offer seamless workflow for key user segments

Recommendations for Interoperability

- Common signal in L1 Band (1575.42MHz) from all GNSS (GPS, GALILEO, COMPASS, GLONASS) can be used for most low cost applications and will minimize the cost of Ag applications.
- The different signals in L1 band (L1 GPS and L1 GLONASS) can help with interference immunity for high precision application (base station, machine control)
- Common wide band signal for all GNSS system in E5 Band (E5a/L5 + E5b/L3/B2 Band) will minimize multipath errors and time-to-fix for high precision application.

