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

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Topcon Positioning Systems

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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
TOPCON

Precision Applications and Products: AGRICULTURE

AGI-3 Receiver
GX-45 Console

MAP
AUTO STEER
ASC
High precision GNSS receiver generations

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

<table>
<thead>
<tr>
<th></th>
<th>% FIX</th>
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<tbody>
<tr>
<td>GPS-only</td>
<td>92 %</td>
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<tr>
<td>GLO-only</td>
<td>87 %</td>
</tr>
<tr>
<td>GPS+GLO</td>
<td>98 %</td>
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- % FIX
- 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

- 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

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<tr>
<td>GLO-only</td>
<td>68 %</td>
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<tr>
<td>GPS+GLO</td>
<td>99 %</td>
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GNSS antennas are shaded by boom
Test rail-way for dynamic tests and collection statistics for agricultural and machine control application

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

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<tr>
<td>GPS-only</td>
<td>99.85 %</td>
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<tr>
<td>GLO-only</td>
<td>96.24 %</td>
</tr>
<tr>
<td>GPS+GLO</td>
<td>100.0 %</td>
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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 $\geq 7$

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

There is no problem with bias/accuracy, GLONASS or GPS, so the same should be true for newer systems.
**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

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<tr>
<td>GLO-only</td>
<td>39.6 %</td>
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<tr>
<td>GPS+GLO</td>
<td>92.4 %</td>
</tr>
<tr>
<td>GPS+GLO+BDS</td>
<td>93.2 %</td>
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- **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
GNSS 10 Years from Now

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.