Advancements in GNSS RTK Technology

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Objectives

Motivated by the resurrection of the Russia's **GLO**bal **NA**vigation **S**atellite **S**ystem (GLONASS), this presentation will look into the current RTK technology and their capabilities.

This presentation will look into –

- Current GNSS Status
- GPS and GLONASS Comparison
- Interoperability Issues
- Field Test Results

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What is GNSS ?

The term "GNSS" stands for Global Navigation Satellite Systems and is the standard generic term for satellite navigation systems that provide autonomous geo-spatial positioning with global coverage.

GNSS Membership

USA (1995) – Declared operational in 1995, GPS is the only fully functional GNSS available today.

Russia (2009) - GLONASS was once declared fully operational in 1993 before reaching a full 24-satellite constellation in 1996. Since then the number of satellites had dropped to the lowest level of 6 in 2001. It will return to a full 24-satellite constellation later this year.

EU (2013?) – Two prototype satellites have been launched to-date (2005 and 2008). Due to funding challenges, the Galileo project suffered critical schedule delays. The current target for completion is 2013.

China (in-progress) – China has announced to launch 3-4 Compass satellites this year and 11 over the next two years. It is unclear when the Compass will be declared fully operational.

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GNSS Parameters

	GPS	GLONASS
First Launched	Feb 22, 1978	Oct 12, 1982
Full Operational Capability	Jul 17, 1995	Jan 18, 1996 and 2009?
Funding	Public	Public
Nominal Number of Satellites	24 (Currently 31)	24 (Currently 20)
Geodetic Reference System	WGS-84	PE-90
Signal Separation	CDMA	FDMA
Frequencies (MHz)	1,575.420 1,227.600	1,602.0 ± 1,246.0 ±

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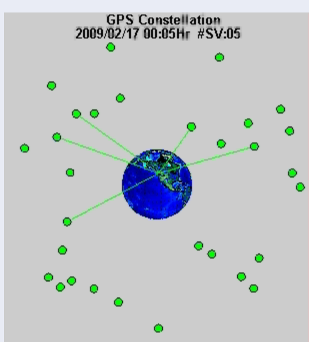
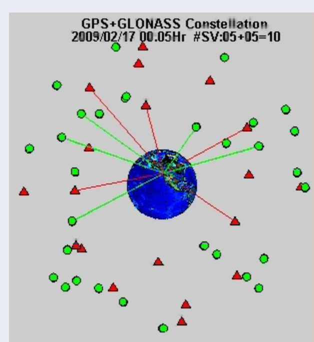
GPS vs GPS+GLONASS





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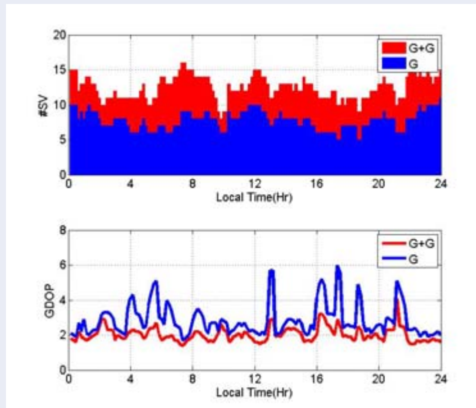
Comparative Satellite Availability

Based on Vancouver satellite visibility at 15^{o} mask angle for Feb 17, 2009



Improvement

24hr Average	GPS-Only	GPS+GLONASS	Improvement
Number of Satellites	7.7	12.4	4.7 (61%)
GDOP	2.8	2.0	0.8 (40%)

An Important Note – Because GPS and GLONASS are not identical, the improvement in RTK performance by additional GLONASS satellites isn't the same as additional GPS satellites.

Practical Implications

- More satellite signals add more to observations; thereby, increase precision and the ability to detect errors.
- Because of the physical limitations which satellite signals must propagate through the atmosphere, the RTK precision will not improve to the millimetres level.
- Even with the increased redundancy, it may not be possible to perform RTK operations in visibly restricted places.

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Interoperability Challenges

The GPS and GLONASS observations can be integrated if the following can be addressed

- Different geodetic reference and the time systems -> can be managed.
- Different radio frequencies and different Channel Access Protocols. GLONASS uses FDMA, while GPS uses CDMA standards. -> more challenging.

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FDMA vs CDMA

- FDMA design requires unique carrier frequencies for all satellites but use the same Pseudo Random Noise (PRN) code.
- CDMA uses the same frequency for all satellites but each uses a dedicated PRN code.

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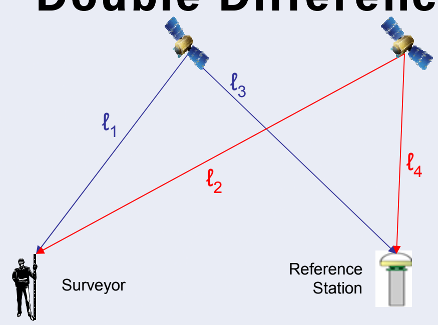
Double Difference (DD) Equation



$$DD = (\ell_1 - \ell_2) - (\ell_3 - \ell_4)$$

- In case of GLONASS-GLONASS or GPS-GLONASS satellite combination, $\ell_{1,3}$ and $\ell_{2,4}$ frequencies are different, the traditional DD equation needs to be modified.
- Modifications have been proposed by Habrich et al. (1999) and Han et al. (1999)

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GNSS RTK Performance Test

- In order to gain an insight into the RTK performance, two identical high-end survey grade rover systems were tested simultaneously over a 12Hr period on Feb 26, 2009.
- For a direct comparison, one rover tracked only GPS signals and the other tracked both GPS and GLONASS signals.

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Test Configuration

- Two GPS+GLONASS rover systems, each equipped with a mobile IP device, shared a common GNSS antenna.
- Each rover streamed NMEA messages to a computer, where data were logged for analysis.
- Both computers were programmed and forced re-initialization process on even 5 minute intervals by blocking the sky view for 1 minute.
- A conservative 15-degree mask angle was used.

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Test Site

- In a residential area, where sky blockage to the east existed.
- About 4km from the base station

South View

East View

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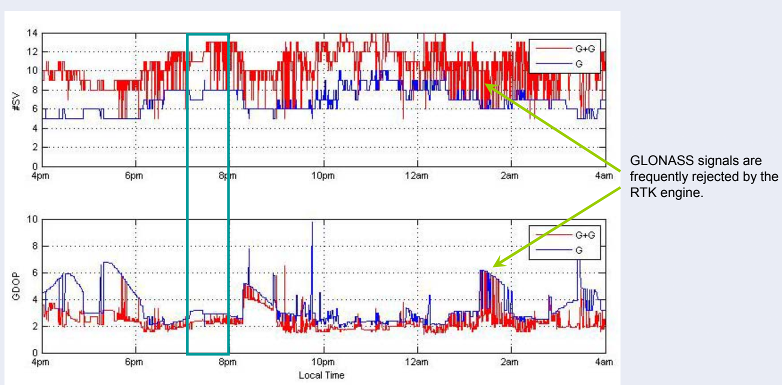
Number of Satellites Utilized



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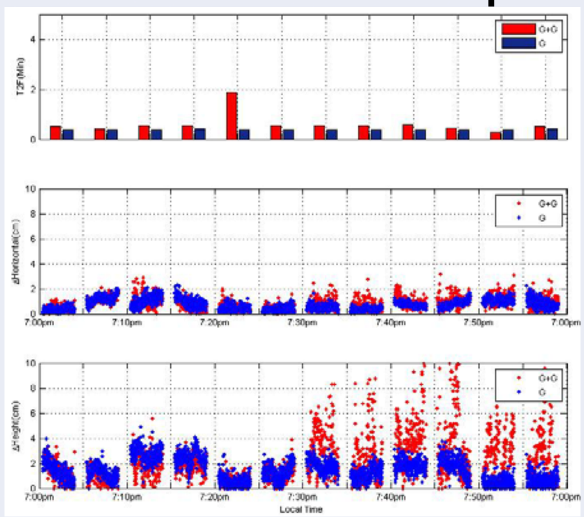
RTK Performance 7-8pm



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Summary

Initialization Performance (12 hrs over 4-minute intervals)		
	GPS	GPS+GLONASS
Initialization Success Rate	91% (131/144)	92% (133/144)
Average Time2Fix	32.7sec	n/a

Precision Performance		
	GPS	GPS+GLONASS
Horizontal @95%	2.2cm	n/a
Vertical @95%	3.4cm	n/a

n/a – not available until results are validated by the system manufacturer.

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Conclusions

- GPS+GLONASS RTK offers significantly more observations.
- There are interoperability challenges between the GPS and the GLONASS.
- Subject to further validation and based on a sample data set, the GPS-only RTK performed just as well, if not better than that of the GPS+GLONASS combination.

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Questions?

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