RTK: Where Every GNSS Matters

Presenter: Sergey Averin, Mathematical Team Leader,
Topcon Technology Center,
Moscow, Russia

What Is RTK?

RTK – Real Time Kinematics:

A methodology to provide real time positioning with an accuracy at centimeter level.

RTK Specifics:

▸ A need for static reference station called 'base'
▸ A need for data link between base and a rover
▸ Carrier phase ambiguity resolution (AR) at rover side is a must in order to achieve centimeter level accuracy

When carrier phase ambiguities are resolved – output solution has status 'fixed' and accuracy of centimeter level

How RTK Is Organized

GNSS Satellites

Correction Data

Positioning Results

Rover

Base
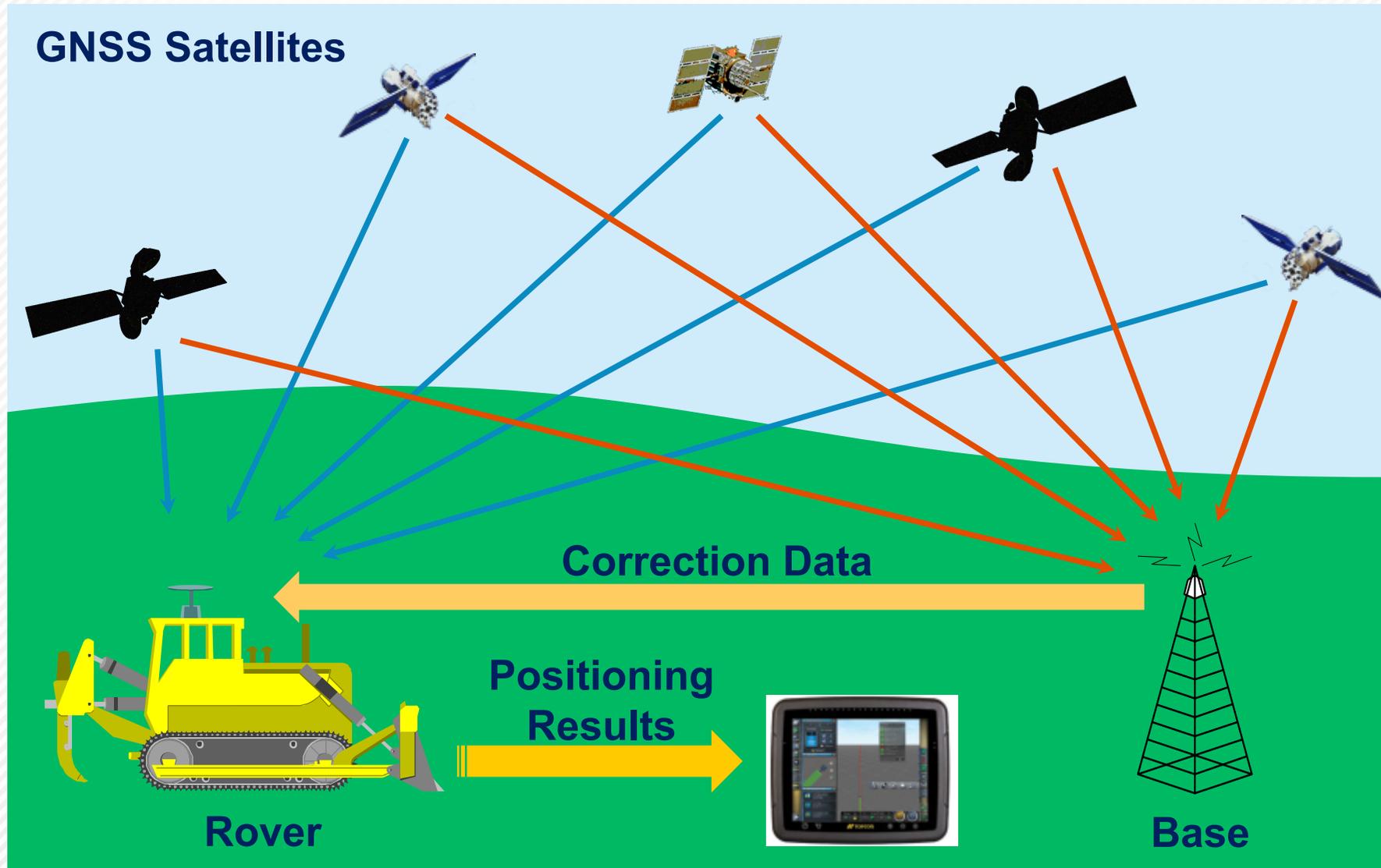
RTK Is Not Always Reliable by 100%

RTK Is Successful If:

▸ **Percentage of 'fixed' solutions is close to 100%**
▸ **RMS positioning errors are on centimeter level**
▸ **Percentage of outliers (wrong fixes) is close to 0**

Typical Example RTK Timeline:
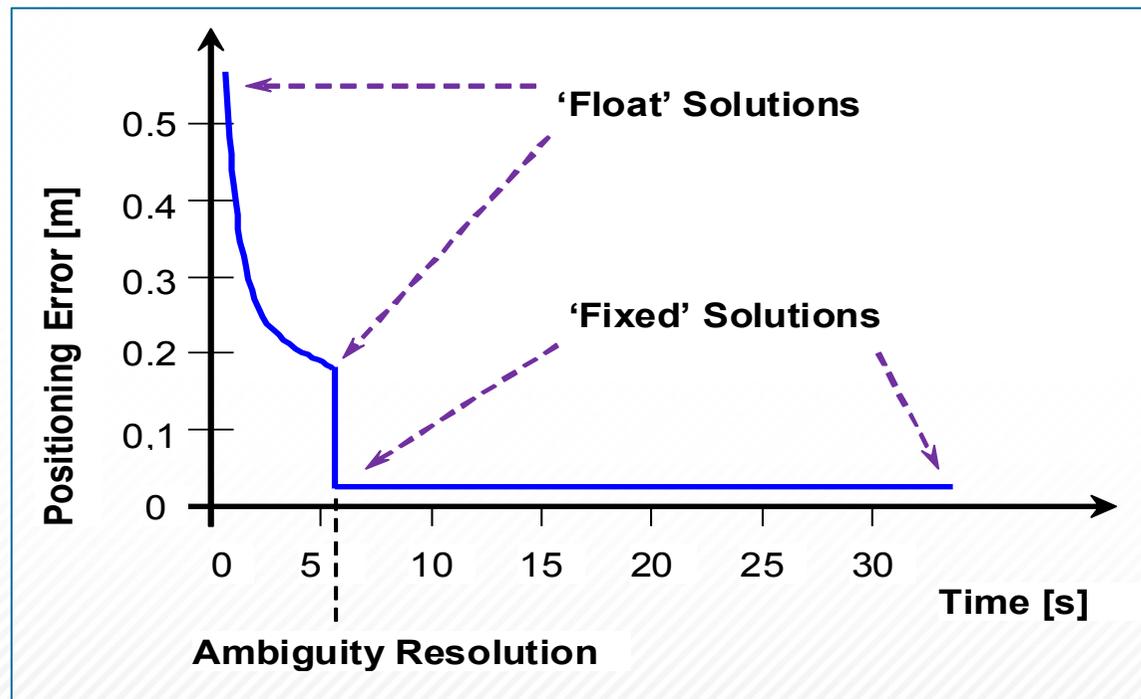
How To Make RTK Reliable by 100%?

▸ To keep baseline short – not always achievable

▸ To keep away from signal obstructions and interferences – not always achievable

▸ To have reliable data link between base and rover – not always achievable

▸ *To track and use as many satellite measurements as possible – achievable with receiver design*

Satellite Signals Available Today for Use in RTK

▸ GPS L1 + GPS L2(L2C): 30-31 NSV in operation

▸ GLONASS L1 + GLONASS L2 (L2C): 24-25 NSV in operation

▸ Beidou B1 + Beidou B2: 14 NSV in operation

▸ SBAS L1: WAAS(3), GAGAN(2), MSAS(2), EGNOS(2)

▸ QZSS L1 + QZSS L2: 1 NSV in operation

Test Results for Open Sky: Moscow, Reset Every 5 Min

Base

Rover

Conclusions

▸ **Under open sky all results are good**

▸ **Adding BDS to GPS+GLO does not help, as BDS geometry in Moscow is not favorable**

▸ **GPS-only and GLO-only are of the same satisfactory quality, but slightly worse than GPS+GLO**

Mode	Stat.	Fix, [%]	RMS, mm		
			N	E	H
GPS/GLO/BDS	79473	100	1.6	1.2	3.0
GPS/GLO	79473	100	1.7	1.2	3.1
GPS/BDS	79473	99.92	2.5	1.7	4.5
GPS Only	79473	97.45	2.8	1.7	4.7
GLO/BDS	79473	99.95	2.1	2.0	4.1
GLO Only	79473	99.77	2.3	2.0	4.3

Test Results for Challenging Conditions: Moscow, Reset Every 5 Min

Base and rover

Conclusions

▸ **The best results are achieved for GPS+GLO combination**

▸ **Adding BDS to GPS+GLO does not help, as BDS geometry in Moscow is not favorable**

▸ **GPS Only and GLONASS Only results are of poor quality**

Mode	Stat.	Fix, [%]	RMS, mm		
			N	E	H
GPS/GLO/BDS	95697	97.75	6.2	5.7	13.3
GPS/GLO	95697	98.06	6.2	5.8	13.2
GPS/BDS	95697	85.05	8.1	6.4	15.2
GPS Only	95696	71.89	7.8	6.4	14.0
GLO/BDS	95697	58.98	9.9	10.3	24.4
GLO Only	95697	38.72	11.3	9.3	21.0

Test Results for Challenging Conditions: Singapore, Urban Canyon

Rover

Conclusions

▸ **The best results are achieved for GPS+GLO+BDS combination**

▸ **GPS Only, GLONASS Only, and even GPS+GLO results are unsatisfactory**

Mode	Stat.	Fix, [%]	RMS, mm		
			N	E	H
GPS/GLO/BDS	3454	93,17	36,5	11,7	25,9
GPS/GLO	3454	0,58	--	--	--
GPS/BDS	3454	92,96	38,0	10,5	28,4
GPS Only	3454	0	--	--	--
GLO/BDS	3454	64,5	35,9	6,8	25,6
GLO Only	3454	0	--	--	--

Test Results for Challenging Conditions: Singapore, Tree Canopy

Rover

Conclusions

▸ **The best results are achieved for GPS +GLO+BDS combination**

▸ **GPS Only, GLONASS Only, and even GPS+GLO results are unsatisfactory**

Mode	Stat.	Fix, [%]	RMS, mm		
			N	E	H
GPS/GLO/BDS	3454	92,27	33,2	12,6	23,8
GPS/GLO	3454	4,88	--	--	--
GPS/BDS	3454	91,16	35,8	15,3	27,1
GPS Only	3454	1,20	--	--	--
GLO/BDS	3454	77,15	38,6	14,8	28,5
GLO Only	3454	0,56	--	--	--

Conclusions

‣ **In favorable conditions (open sky, no interferences) every GNSS alone can provide reliable RTK solution (GPS, or GLONASS, or BDS).**

‣ **In difficult conditions none of the GNSS alone can provide any reliability; only combined use of all available GNSS signals is capable to provide needed quality of RTK results.**

‣ **Adding GLONASS to GPS is crucial for providing high quality RTK solutions all over the World.**

‣ **In Eastern regions of the World the use of BDS signals in addition to signals of GPS and GLONASS makes RTK even more efficient.**

‣ **With expected further populating the BDS constellation with MEO (Medium Earth Orbit) satellites, RTK performance should improve globally (starting with 2015).**

‣ **The future in high precision RTK applications belongs to multisystem receivers: GPS+GLONASS+Beidou**