Swedish User Guidelines for Network RTK

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Background and objectives

RTK (Real Time Kinematic) is an effective technique for accurate positioning in real time with GNSS. The development of the network RTK services based on permanent GNSS reference stations, e.g. SWEPOS™ in Sweden, has made it possible for basically anyone to use the technique. The need of user guidelines for this technique is essential.

Serious errors can be introduced into the positioning if the user has no, or only modest, knowledge/information of the factors affecting the network RTK observations, e.g.:

- the satellite constellation
- different settings in the receiver
- multipath errors
- atmospheric errors (ionosphere, troposphere)
- etc.

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Settings and quality indicators in the GNSS receiver:

- The elevation cut off angle is recommended to 13-15 degrees for today's satellite constellation
- PDOP recommendations are set to maximum 3-4 depending on the precision requirements (even a maximum of 2 if high precision is necessary)
- The instrument-reported coordinate quality measures should, for the most manufacturers, be multiplied by two (2σ) to be at least 95% confident that the measurements are within the desired accuracy level.
- Note that multipath effects for a short period of time (seconds to minutes) are not included and modeled into these instrument-reported values

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An example of a precision and PDOP limit in a difficult area (Edwards et al. 2008)

Coordinate Quality filter

Site Name		GRAS		
		North	East	Up
Purple	min (mm)	-62	-41	-2470
	max (mm)	1263	1220	143
	mean (mm)	22	22	-43
	rms (mm)	134	123	261
	Mean CQ	4.380	3.922	6.680
Pink	min (mm)	-55	-45	-129
	max (mm)	65	59	119
	mean (mm)	9	8	-9
	rms (mm)	16	14	34
	Mean CQ	1.228	1.124	1.533

Coordinate Quality + DOP filter

Site Name		GRAS		
		North	East	Up
Purple	min (mm)	-62	-31	-129
	max (mm)	84	70	142
	mean (mm)	10	-9	-14
	rms (mm)	23	18	38
	Mean CQ	0.688	0.530	0.604
Pink	min (mm)	-55	-45	-129
	max (mm)	65	59	119
	mean (mm)	9	8	-9
	rms (mm)	16	14	34
	Mean CQ	1.231	1.124	1.533

- Despite a precision limit of 50 and 100 mm in the horizontal and the vertical component respectively, the results reveal low accuracy in a multipath affected area
- However, the PDOP limit improved the accuracy significantly
- This would suggest that DOP limit of 3 in challenging areas radically improves the system reliability

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Swedish User Guidelines cont.

Other parameters to consider while surveying:

- Maximum of 1-2 minutes of initialization time is recommended depending on the precision requirements!
- The GSM/GPRS communication should be continuous, a possible indicator in the receiver is quality of radio link
- Pay attention to the SNR (Signal to Noise Ratio) for an indication of possible multipath errors, atmospheric disturbances, radio frequency collisions, etc. Read the manufacturer's manual for the presentation and the warning level

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FIG Sydney
2010-04-15

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Swedish User Guidelines cont.

Surveying and control procedures:

- Minimum averaging recommendation is set to 3 measurements (preferably 3-30) to mitigate GNSS noise and to find gross errors
- Control of **"known" points** or **revisits** of points during field work can also be used to check all points measured with a certain fixed solution or to check the recently obtained fixed solution.
- An accepted deviation for a **revisit** might be up to ± 60 mm horizontally and ± 80 mm vertically (95 % confidence level and no tripod used)[1].

1 Based on the error propagation law with $\sigma_{horizontal}$ and σ_{height} of 15 mm and 27 mm respectively ($\sigma_{centering}$ of 14 mm)

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FIG Sydney
2010-04-15

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Revisit

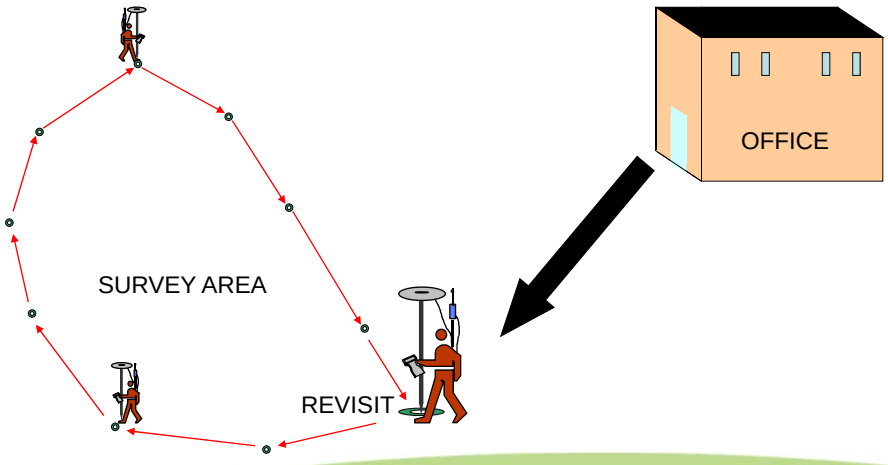

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FIG Sydney
2010-04-15

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Swedish User Guidelines cont.

Control procedures cont.:

- When revisiting it is important to use a time separation of at least 5-10 minutes, even though **20-45 minutes** or more are preferred to reduce time correlation effects (e.g. by receiving a different satellite constellation) and to assure a more confident estimation of the obtainable accuracy

- Additionally it should be noted that revisits can be used to increase the accuracy in measured points by averaging (with a sufficient time separation, 20-45 minutes or more).

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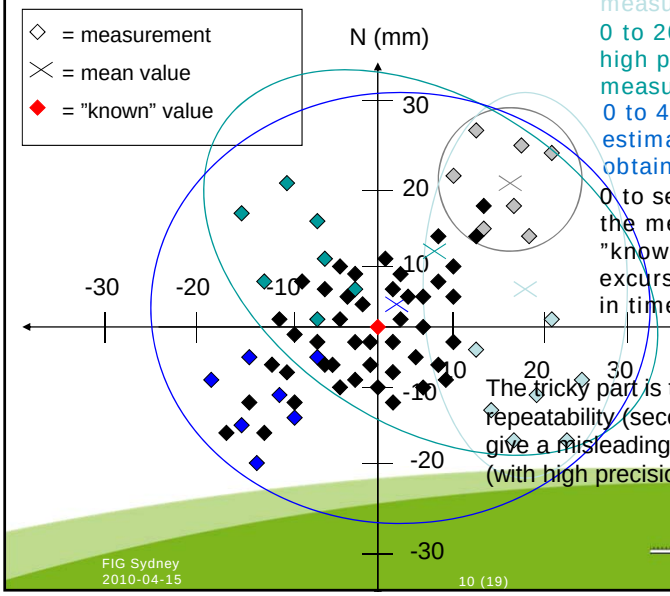
Revisit of a point- the problem with correlations in time



0 to 5 min: low accuracy, high precision

0 to 10 min: low accuracy, high precision for new measurements (5-10 min)

0 to 20 min: better accuracy, high precision for new measurements(10-20 min)

0 to 45 min: a “true” estimation of the accuracy obtained

0 to several hours: most of the measurements close to the ”known” value with some excursions due to correlations in time

The tricky part is that short term repeatability (seconds to minutes) can give a misleading impression of accuracy (with high precision)!

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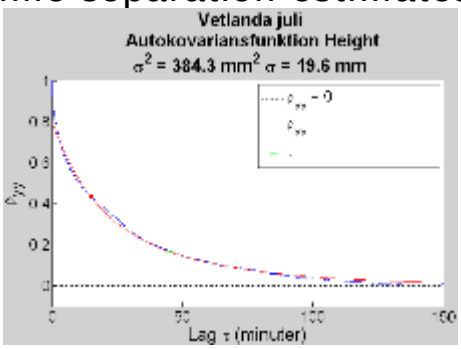
Time separation estimates:



Modelled as a kind of Gauss Markov process

Time separation (minutes)	PRTK τ	PRTK Ω	NRTK τ	NRTK Ω
Horizontal	27,5	25,4	26,8	22,4
height	35,0	24,9	49,5	41,4

Reference: *Odolinski R, 2010:* Study of accuracy and correlations in time for Network RTK. Rapportserie: Geodesi och Geografiska informationssystem, 2010:2, Lantmäteriet, Gävle. (In Swedish). In prep. for a shorter and improved article in English

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FIG Sydney
2010-04-15

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Swedish User Guidelines cont.

Control procedures cont.:

- An accepted deviation for a control of a **known point** might be ± 40 mm in the horizontal and ± 60 mm in the vertical component (at least 95 % confidence level and no error in the known point)[2].

2 Based on the error propagation law with $\sigma_{horizontal}$ and σ_{height} of 15 mm and 27 mm respectively ($\sigma_{centering}$ of 14 mm)

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FIG Sydney
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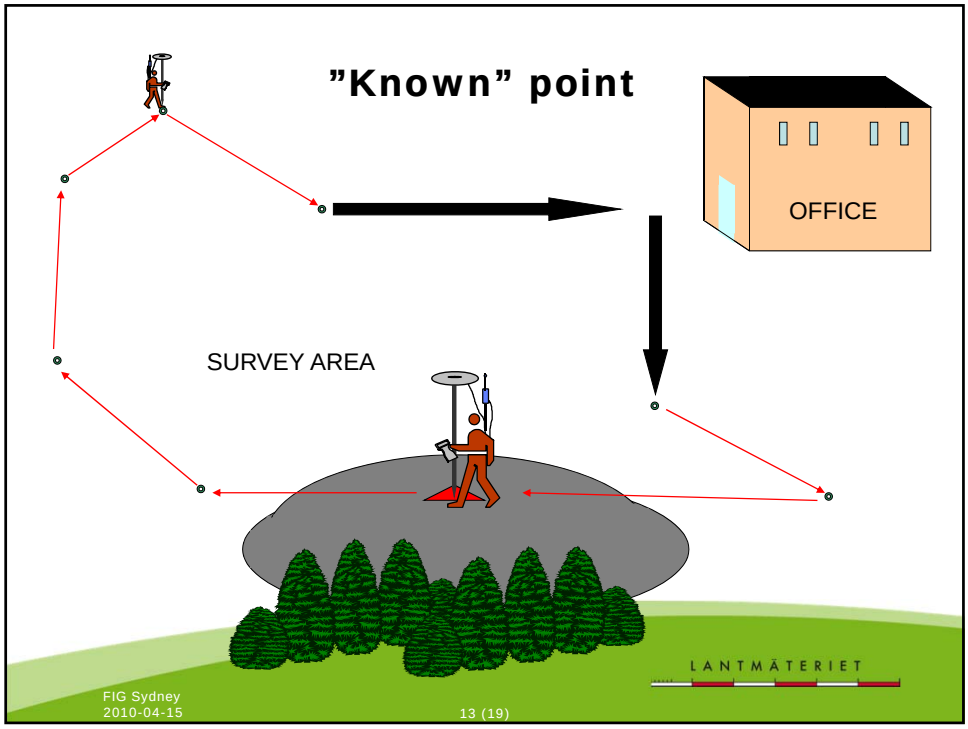

Swedish User Guidelines cont.

Control procedures cont.:

- Use a **"check point"** close to the office on a regular basis (before and after surveying) to control the settings in the receiver, to investigate if atmospheric disturbances affected the network RTK measurements, etc.

- An accepted deviation from a **check point** might be ± 30 mm horizontally and ± 50 mm vertically (95 % confidence level, tripod used and no error assumed in the check point)[3]

3 Based on the error propagation law with $\sigma_{horizontal}$, σ_{height} and σ_{geoid} of 15 mm, 27 mm and 15 mm respectively

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FIG Sydney
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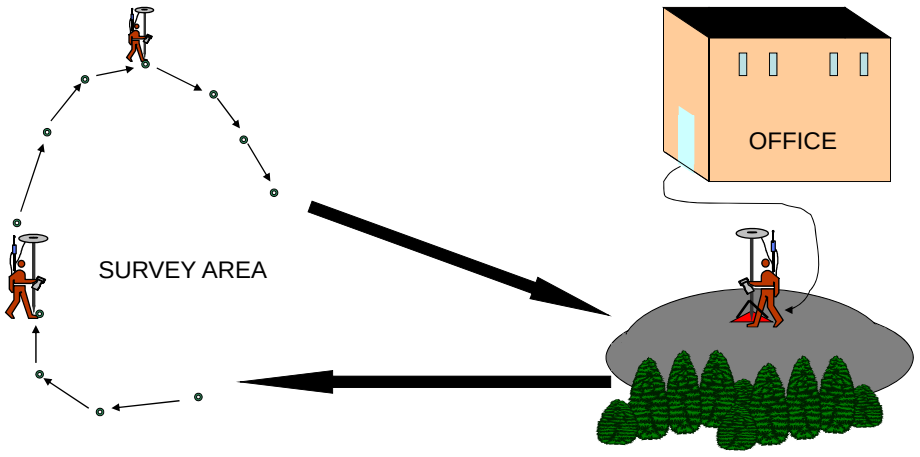
Check point close to office



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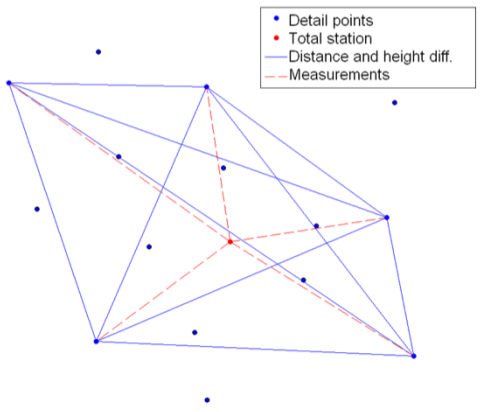
Control method: ”Separate control with conventional technique”



- The detail points are measured with a total station (free stationing) in a local system
- The measured detail points are then compared to the network RTK points

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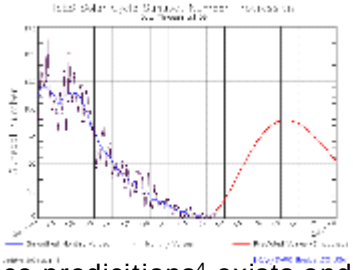
Sun spot activity (increases the number of free electrons in the ionosphere)

- Sun spot maximum in year 2013, will probably mostly affect the vertical component



- Daily space predicitions[4] exists and tells the user if it is ”OK” to use the RTK-technique
- The alternative is to control a ”check” point close to the office which will give an indication of possible problems
- SWEPOS™ (Swedish CORS Network) have plans to present real time solar activity reports at http://www.swepos.com

4 http://www.swpc.noaa.gov/NOAAscales/index.html

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Discussion

- The recommendations will probably improve over the years, and it is of great importance to keep the guidelines updated
- The accuracy levels will most likely improve with additional satellite constellations, e.g. Galileo.
- In the future guidelines for GNSS integrated with a totalstation (e.g. Leica Smartstation or Trimble IS Rover), or possible integrated with INS (Inertial Navigation Systems), will be an important issue to consider.

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References

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Odolinski R, 2010b: Study of accuracy and correlations in time for Network RTK. Improved and shortened article of the report above, in process.

Odolinski R, 2010c: User Guidelines for Network RTK. Rapportserie: Geodesi och Geografiska informationssystem, 2010:3, Lantmäteriet, Gävle. (In Swedish)

Thank you for listening!

Questions?

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