Single-frequency receivers as master permanent stations in GNSS networks: precision and accuracy of the positioning in mixed networks

A. CINA, P. DABOVE, A.M. MANZINO

Dipartimento di Ingegneria dell'Ambiente, Territorio ed Infrastrutture (DIATI)
Politecnico di Torino

C.so Duca degli Abruzzi 24, 10129 Torino
(alberto.cina, paolo.dabove, ambrogio.manzino) @polito.it

Memorial Manzoni **Trieste, 18-20 February 2016**

INTRODUCTION - GOAL

The use of low-cost GPS instruments leads to have some problems, as:

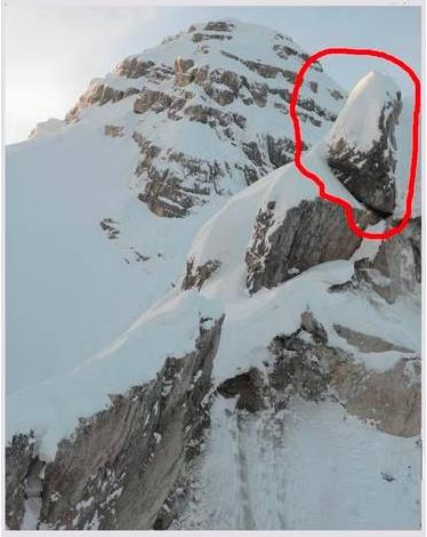
- the use of algorithms able to fix the phase ambiguities in short time (few sec) without considering dual-frequency approach
- limited distances between master and rover both for RT (real-time) and PP (post-processing)

The goal of this work is focusing the attention on the usefulness of single frequency permanent stations in order to thicken the existing CORSs, especially for monitoring purposes.

The use of these receivers allow to have a more dense network

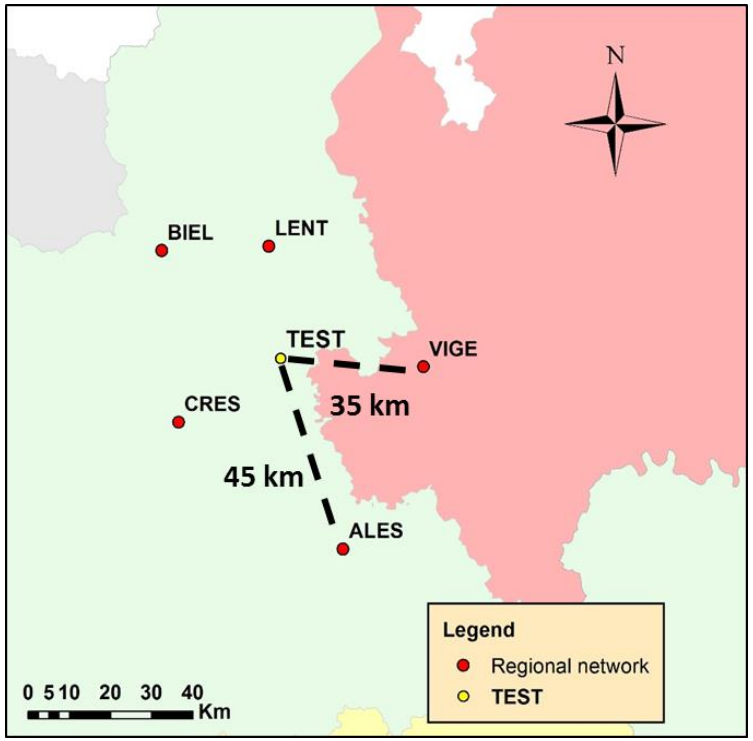
more spread instruments with the same costs

For which purposes?

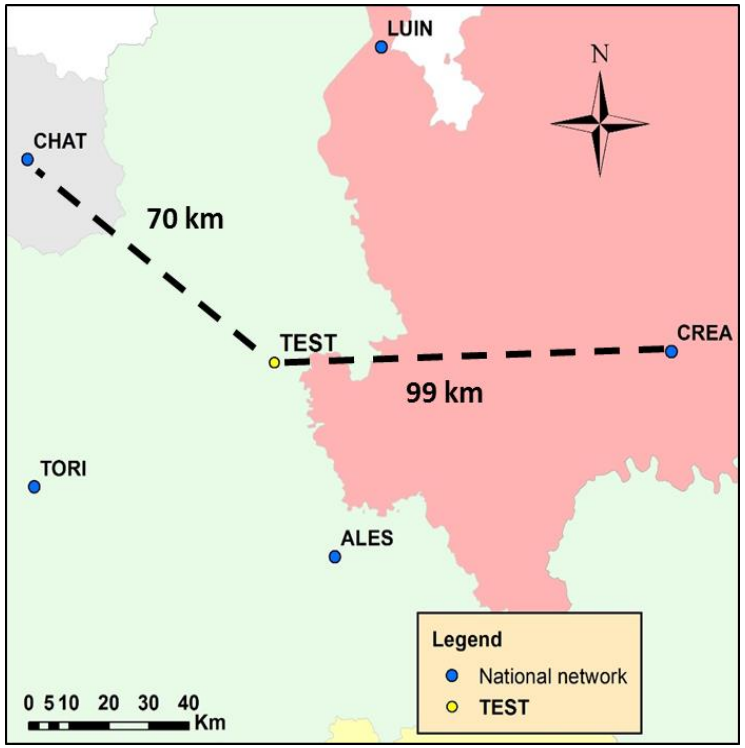


Typical inter-station distances in Italy

Regional



National



The use of low-cost GPS instruments brings to have several critical aspects:

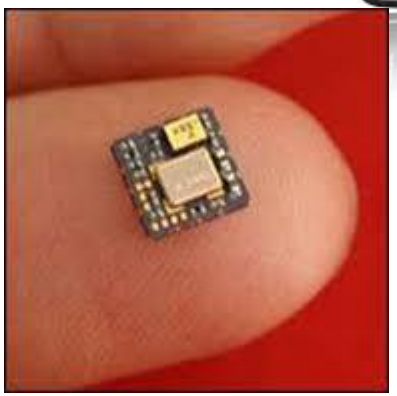
1. the accuracy of the rover positioning;

2. the use of particular algorithms which are able to fix the phase ambiguity in a very short time (few seconds) without the use of both frequencies;

3. a limited length of the baseline between master and rover, both in real time and in post-processing approach.

What is "mass market" for us?

We call "mass-market" the GPS instruments with a cost less than 500 € (or 650 $) which are able to track the C/A code and, if it is possible, even L1 carrier phase measurements.



INSTRUMENTS CONSIDERED

Receivers		
	LEA EVK-5T (u-blox)	**Leica 1230GX+ GNSS (Leica Geosystems®)**
Default Antenna	patch	geodetic
GNSS constellations	GPS+SBAS	GPS + GLONASS + Galileo
Observations	GPS: C/A, L1, Doppler, S/N	GPS: C/A, L1, L2, L5 Doppler, S/N GLONASS: L1/L2, Galileo:E1, E5a, E5b, Alt-BOC
Acquisition rate	0.25 ÷ 1000 Hz	0.2 ÷ 100 Hz
Type of corrections	RTCM 2.x, RTCM 3.0, SBAS (WAAS/EGNOS/MSAS/GAGAN) Owner corrections (AssistNow Online & Offline)	RTCM 2.x RTCM 3.0 CMR / CMR+

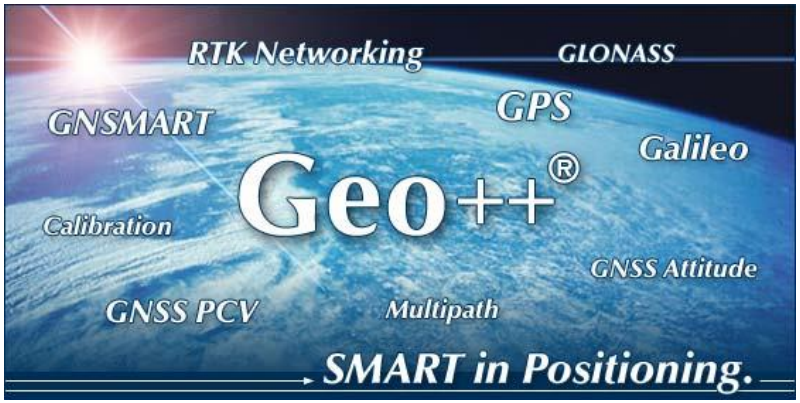
INSTRUMENTS CONSIDERED

Type of antenna	Garmin GA38	LEIAX1203+ GNSS
Image		
Gain	about 27 dB	≈17 dB
Cost	about 40 €	about 1000 €

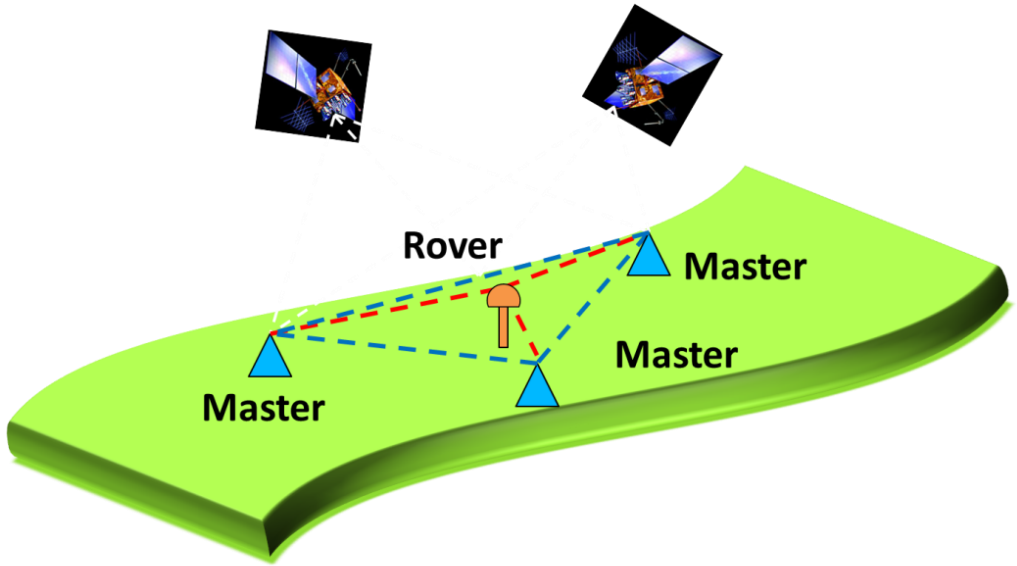
Network software considered

Leica GNSS Spider v.4.3.0.4633

GNSMART v. October 2013



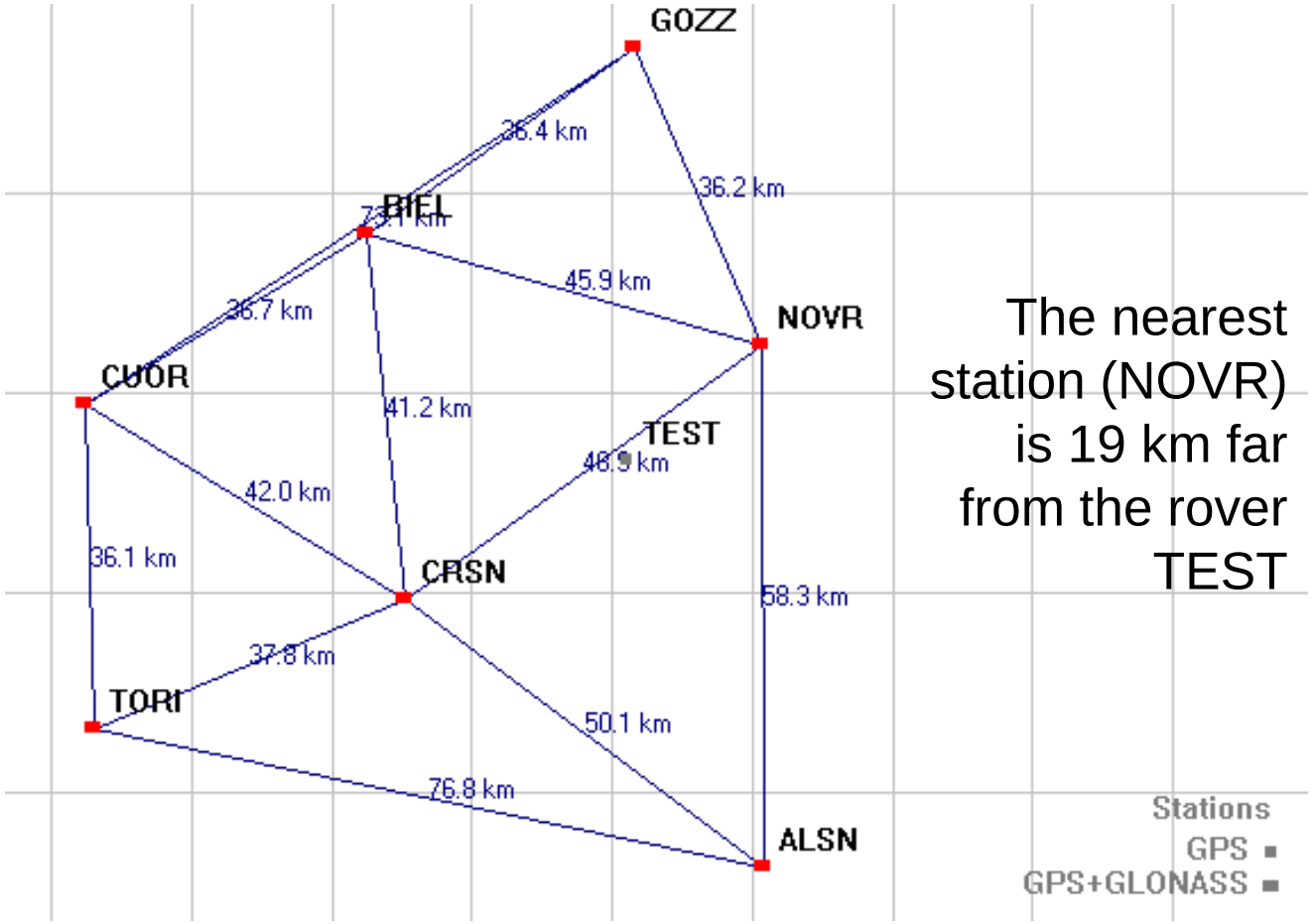
Main NRTK corrections



The control center broadcast the differential corrections to the rover:

- NRT (Nearest) correction
- VRS (Virtual Reference Station) correction
- FKP (Flächen Korrektur Parameter) correction
- MAC (Master Auxiliary concept)

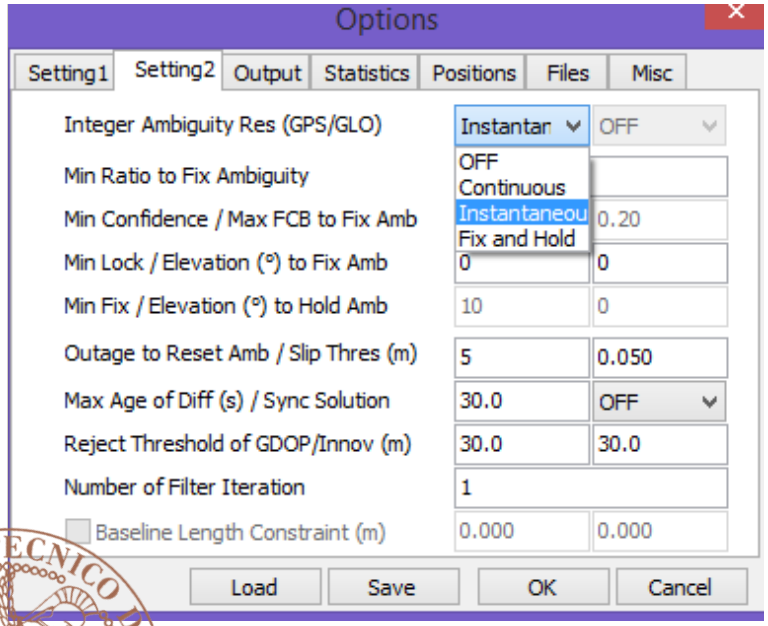
We have considered a network with mean inter-station distances of about 40 km.



The nearest station (NOVR) is 19 km far from the rover TEST

Software

To perform the NRTK positioning the routines RTKLIB V. 2.4.2 were used (http://www.rtklib.com/). In particular for these experiments the RTKNAVI tool was used.



It is also possible to set a threshold ratio to fix ambiguities.

$$\frac{\left(\sigma_0^2\right)_{2nd}}{\left(\sigma_0^2\right)_{1st}} \geq ratio = 3 \Rightarrow \text{FIX}$$

Time to fix (TTF)

It is very interesting to know the Time To Fix (TTF) period: it means the time that the receiver needs to fix the phase ambiguity.

-3 days of acquisition
-acquisition rate = 1 s
-“instantaneous” method of ambiguity resolution

Correction type	*mean TTF*	*max TTF*
VRS	87 s ± 23 s	243 s
NRT	115 s ± 52 s	351 s

VRS® correction provides the “best” results

Positioning accuracy in terms of differential corrections

RTKNAVI configuration	*Differential correction*	*2D accuracy at 95%*
Kinematic **fix** and hold	VRS	< 0.05 m
	NRT*	~ 0.04 m
Static **Fix** and Hold	VRS	~ 0.02 m
	NRT*	0.03 ÷ 0.04 m

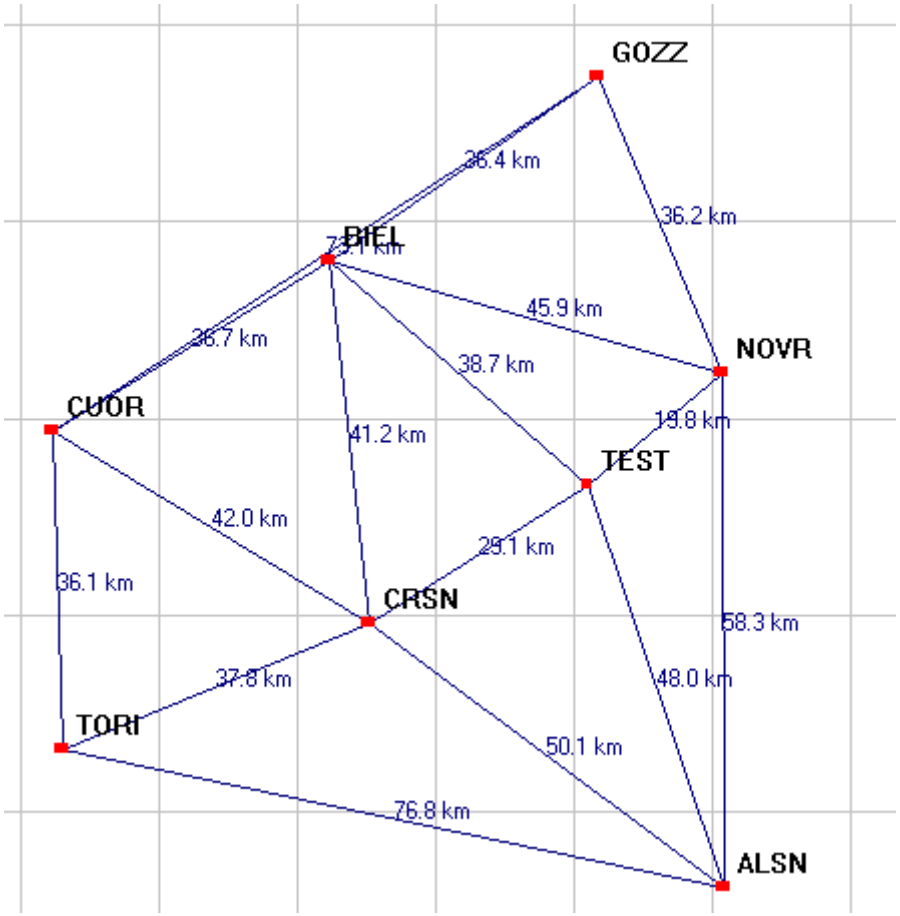
* About 19 km far from the rover

The quality of the positioning is very good!

Worst case: the error positioning is less than 5 cm at 95% of accuracy

A more "dense" network

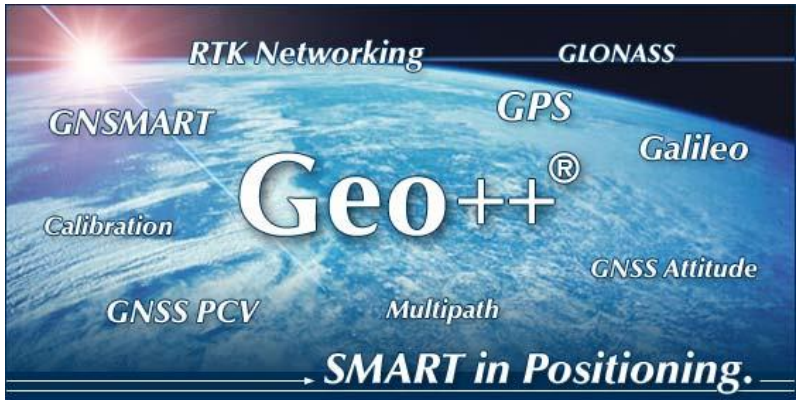
Now TEST is considered as master station



Network software considered

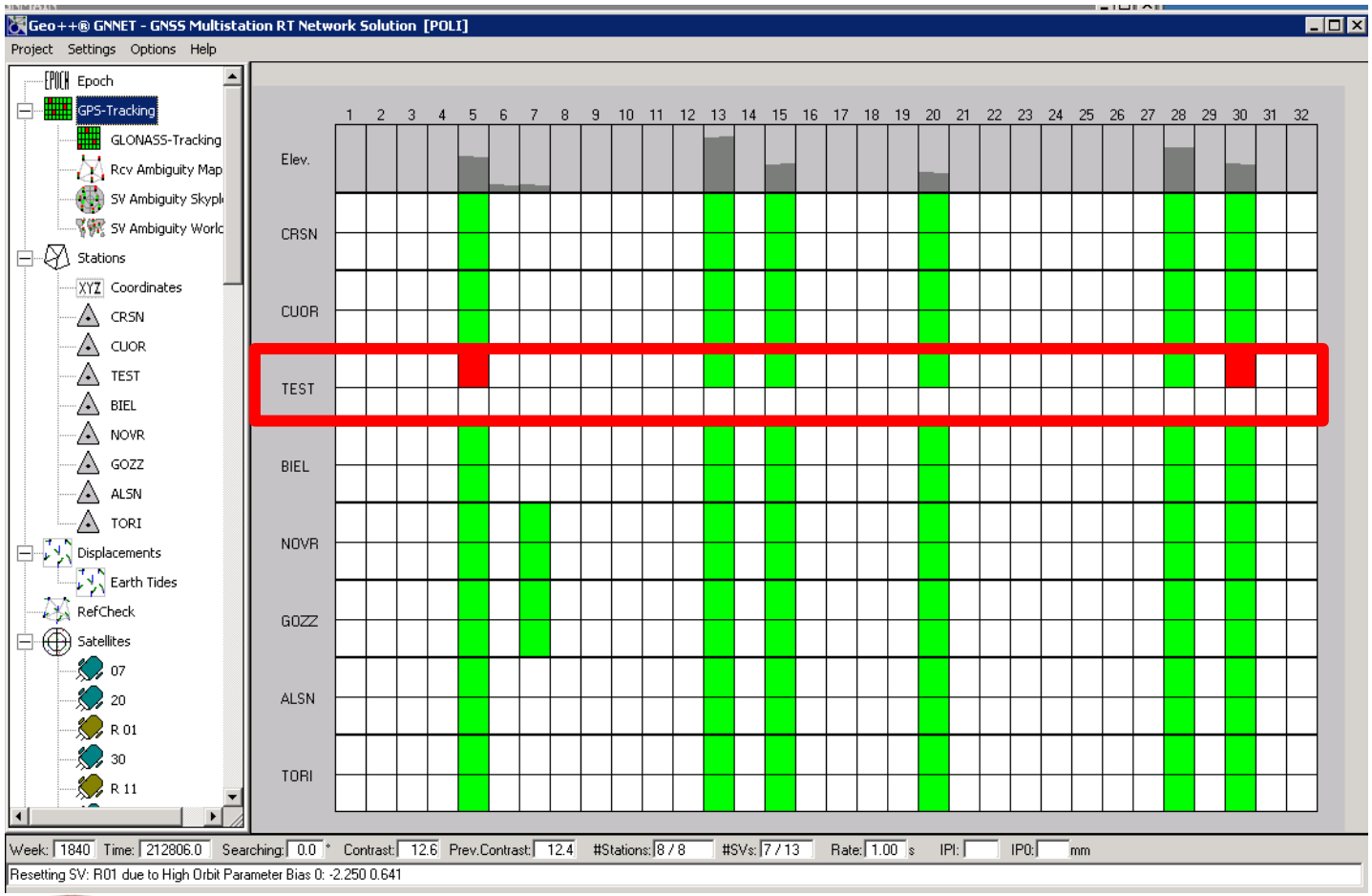
Leica GNSS Spider v.4.3.0.4633

GNSMART v. October 2013



Considering GNSS Spider software it is not possible to insert a L1 receiver in the network solution

MIXED NETWORK L1+L2



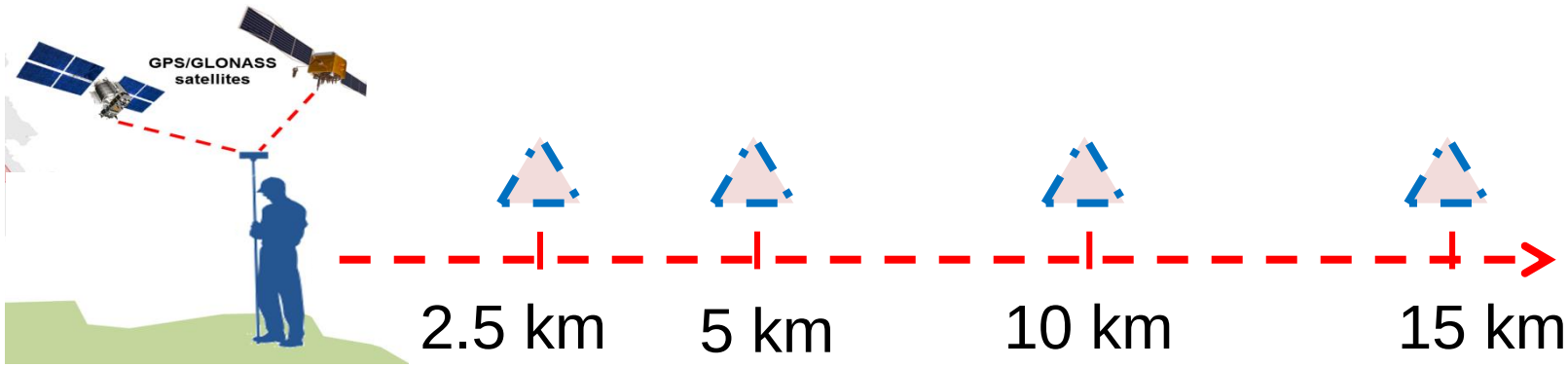
TEST is an L1 receiver

The phase ambiguities of all stations are fixed

8 mins are the TTF for the network

A.CINA, P. DABOVE, A.M. MANZINO

GNSS NRTK positioning obtained with L1 GPS receiver and Garmin antenna



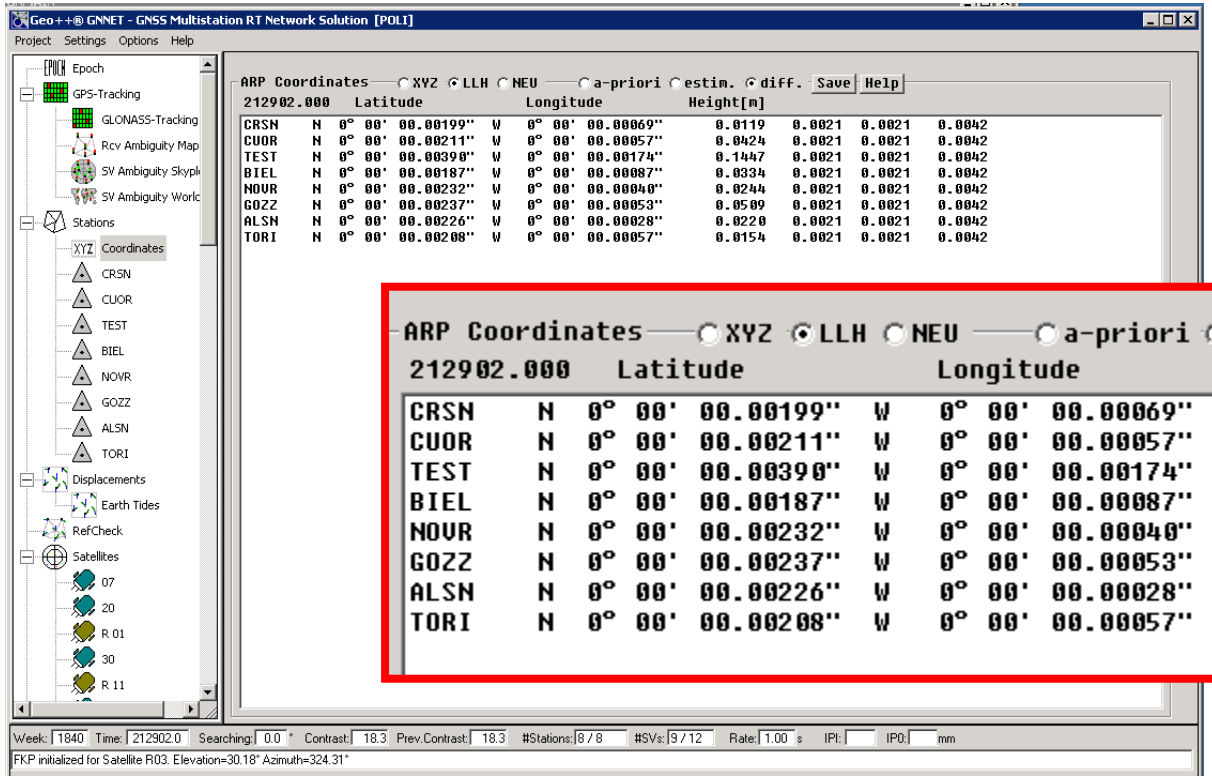
- VRS® correction
- Positioning update equal to 1 Hz
- RTKNAVI tool for NRTK positioning

Acceptable FLOAT solutions (differences of about 5-10 cm with respect to reference) are obtained

NO FIX epochs for rover receiver are available!!

MIXED NETWORK L1+L2

To monitor the differences between *a-priori* and estimated coordinates for all master stations in real-time.



A.CINA, P. DABOVE, A.M. MANZINO

Real-time approach in geodetic network:

Considering only the geodetic network, a centimetric accuracy is available even if L1 GPS receivers are considered as rover. The reliability of the solution depends by the differential correction considered and, obviously, by the inter-station distances between CORSs.

The mean time that an user must wait to make a positioning with fixed phase ambiguity is about 2 mins.

Considering a mixed L1/L2 network:

no FIX solutions for the rover can be obtained with GNSMART!

FLOAT solutions are however good: the accuracy is about 5 cm in plan and 7 cm in up

Despite that, a FIX network solution is available if L1 receiver is a master station

New possible solution: monitoring networks in RT

to consider all L1 receivers as master stations and to monitor their coordinates estimated by network software

Single-frequency receivers as master permanent stations in GNSS networks: precision and accuracy of the positioning in mixed networks

Authors: Alberto Cina (alberto.cina@polito.it)
Paolo Dabove (paolo.dabove@polito.it)
Ambrogio M. Manzino (ambrogio.manzino@polito.it)

Memorial Manzoni Trieste, 18-20 February 2016