GNSS/INS positioning for mobile mapping: analysis and performances in critical situations

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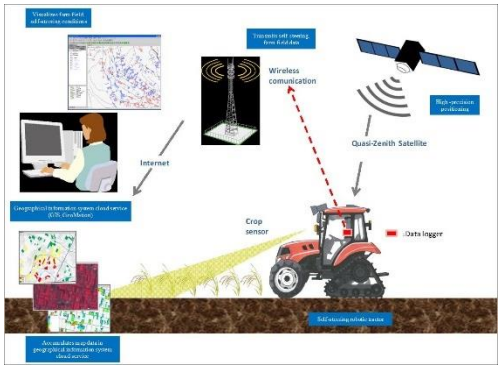
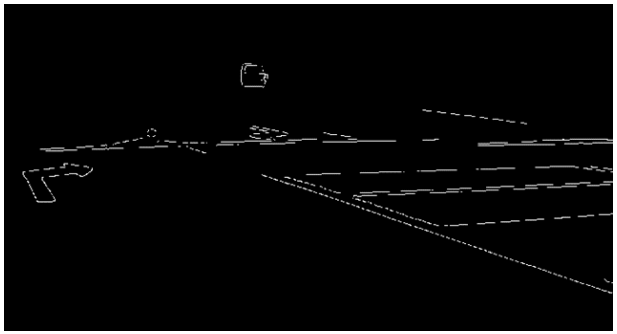
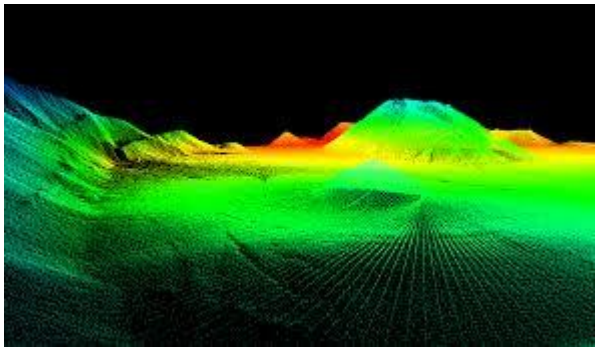
The application field of INS are many



Precise farming



Road extraction



Terrain analysis

Machine control

Update cartography

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INTRODUCTION - GOAL

One of these is a Mobile Mapping (MM) positioning

A mobile mapping system consists of:

- a moving platform (typically a land vehicle);
- navigation sensors (typically GNSS and INS instruments);
- mapping sensors, such as cameras, laser scanners or radar

This work analyzes the current accuracy obtainable from a navigation system for mobile mapping applications related to road detection or for updating large-scale cartography.

In order to answer the question «directly on site»

How can be long the outages to obtain accuracies useful for my MM application?

Two different approaches can be followed:

1. the “geodetic guidance”
   When it is necessary to have an accurate real-time solution

2. **the “geodetic navigation”**
   Data can be acquired onboard and treated in post-processing

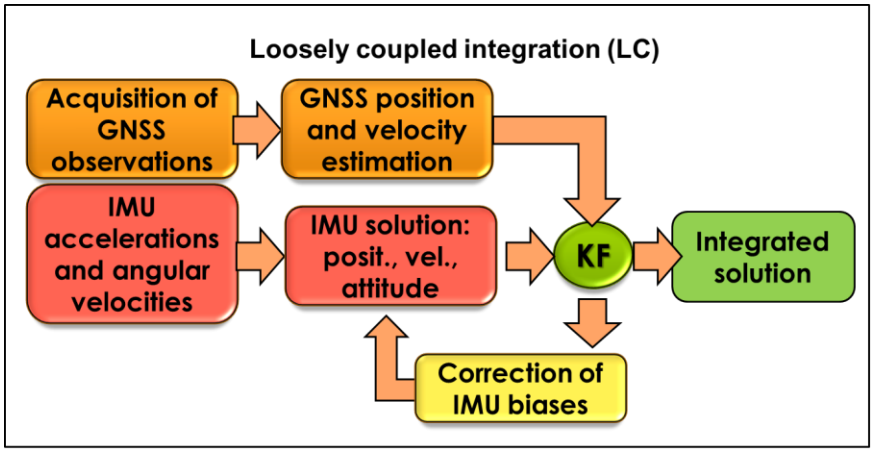
And two post-processing techniques can be considered:

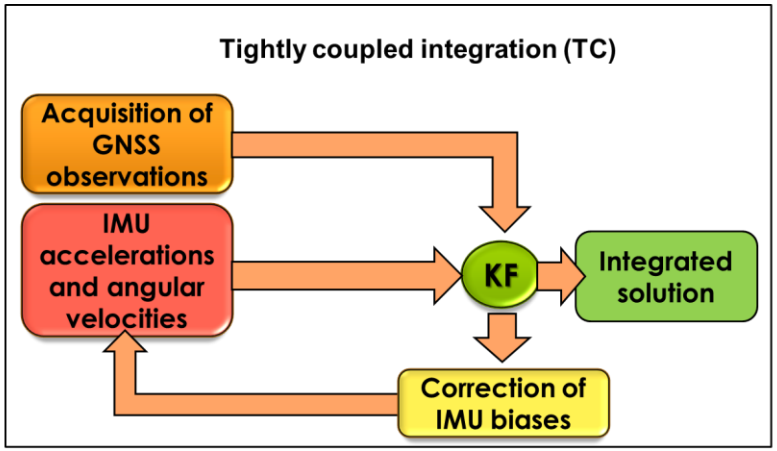
1. The “loosely coupled” (LC) approach
2. The “tightly coupled” (TC) approach

The two PP techniques considered:

1. The “loosely coupled” (LC) approach
2. The “tightly coupled” (TC) approach

The first use the output of the position of two instruments

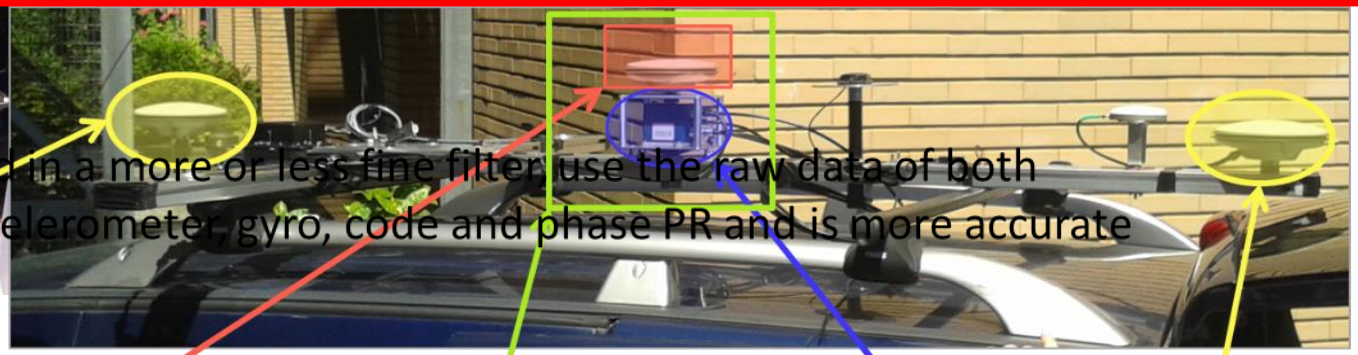




The second, used in a more or less fine filter, use the raw data of both instruments: accelerometer, gyro, code and phase PR and it’s more accurate

INSTRUMENTS CONSIDERED

To perform this test we have mounted Ekinox system ona aluminium cross bar w. 2 antennas aft & bow and one antenna centered in INS center



The second, used in a more or less fine filter use the raw data of both instruments: accelerometer, gyro, code and phase PR and is more accurate

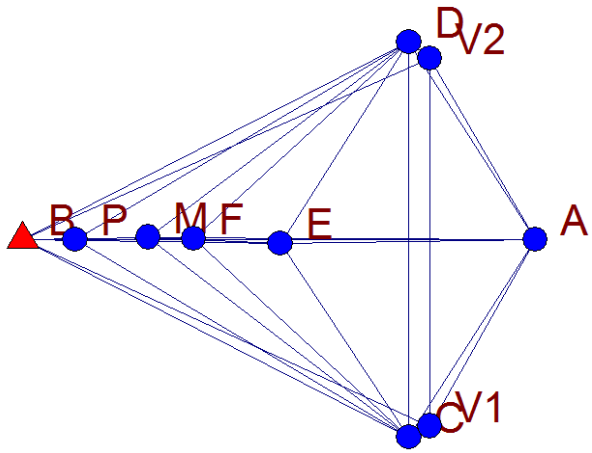
Leica 1230+GNSS

SBG Ekinox-D

Antenna Novatel 702GG

THE CALIBRATION PHASE

Level-arm lab. calibration:



The positions of instrumentation were adjusted both in plan and altimetry by a small network of distances, (following a LS approach), reaching a maximum root mean square error of about 2 mm

External calibration:

To calibrate «run to run» biases of Ekinox with acelerations, turn clockw. & counterclockw.

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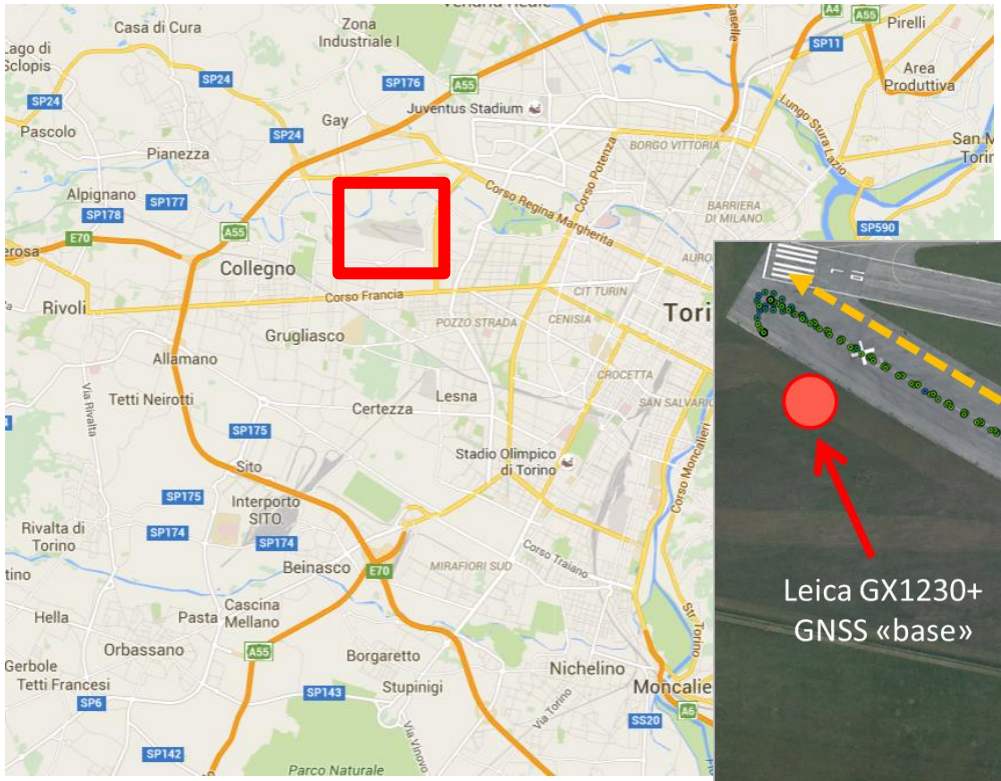
TEST SITE

The measurements were carried out in the Torino-Aeritalia airfield in Turin on a day when there were no take offs or landings



2 Hz is the master GNSS data rate acquisition

The path whose run more times withouth stops

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POSITIONING RESULTS: COORDINATES

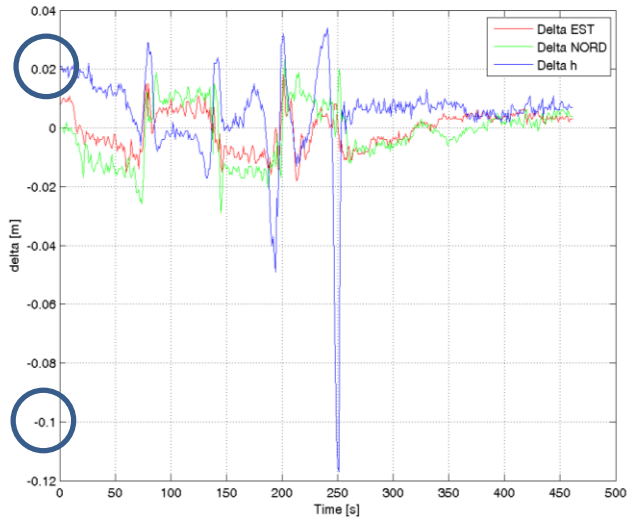
After the run we have computed in PP the accurate position of the antenna, centered on INS

The comparison with 100Hz Inertial and GNSS post processing position give residual

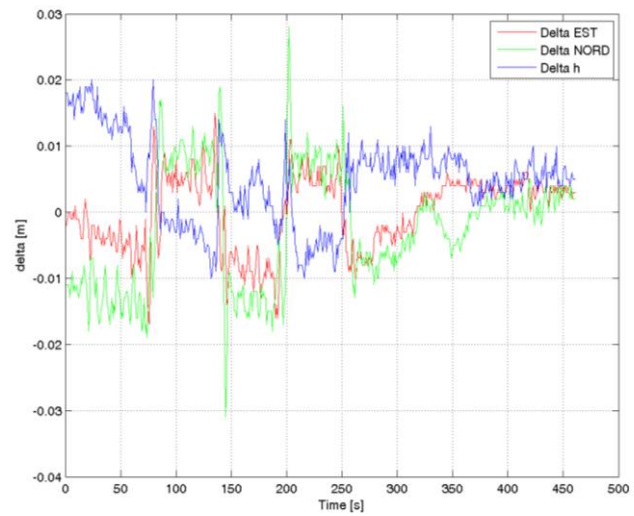
LC processing

0,02 m

-0,1 m



TC processing



Processing strategy	Average Δ2D ± σ [cm]	Average Δh ± σ [cm]
LC	1.5 ± 0.5	0.3 ± 1.0
TC	1.3 ± 0.4	0.2 ± 0.7

That confirm the accuracy at centimetric level

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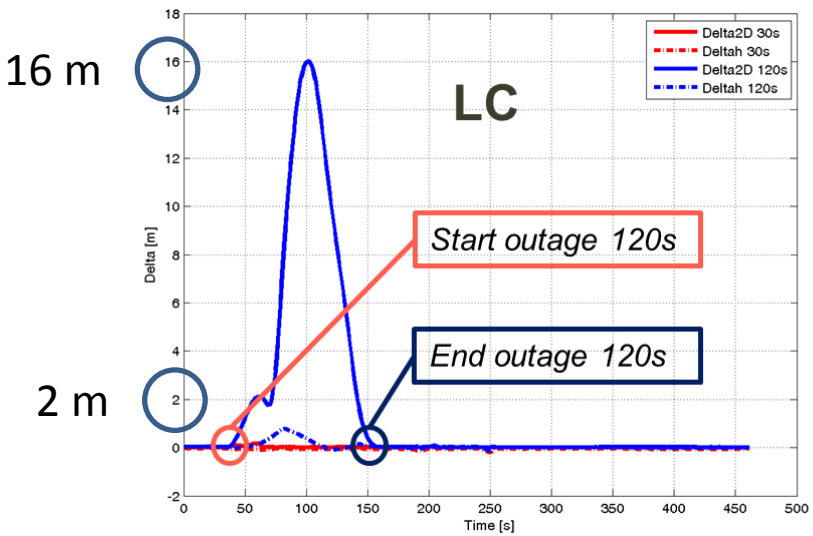
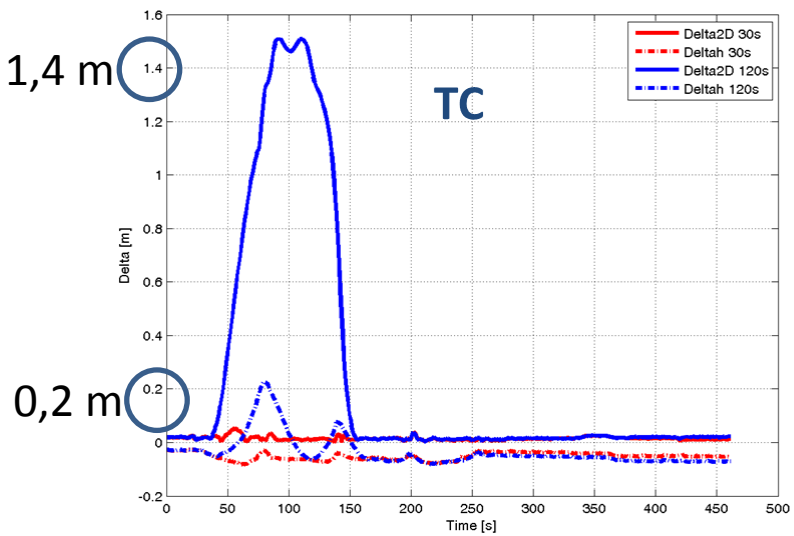
POSITIONING RESULTS: COORDINATES

Using as reference positions: GNSS post-processing solution, we have made in RINEX data man made outages: 30s, 60s, 120s and have recomputed the trajectory (w. inertial explorer®) and finally we have made the comparison





PLANIMETRIC COMPARISON

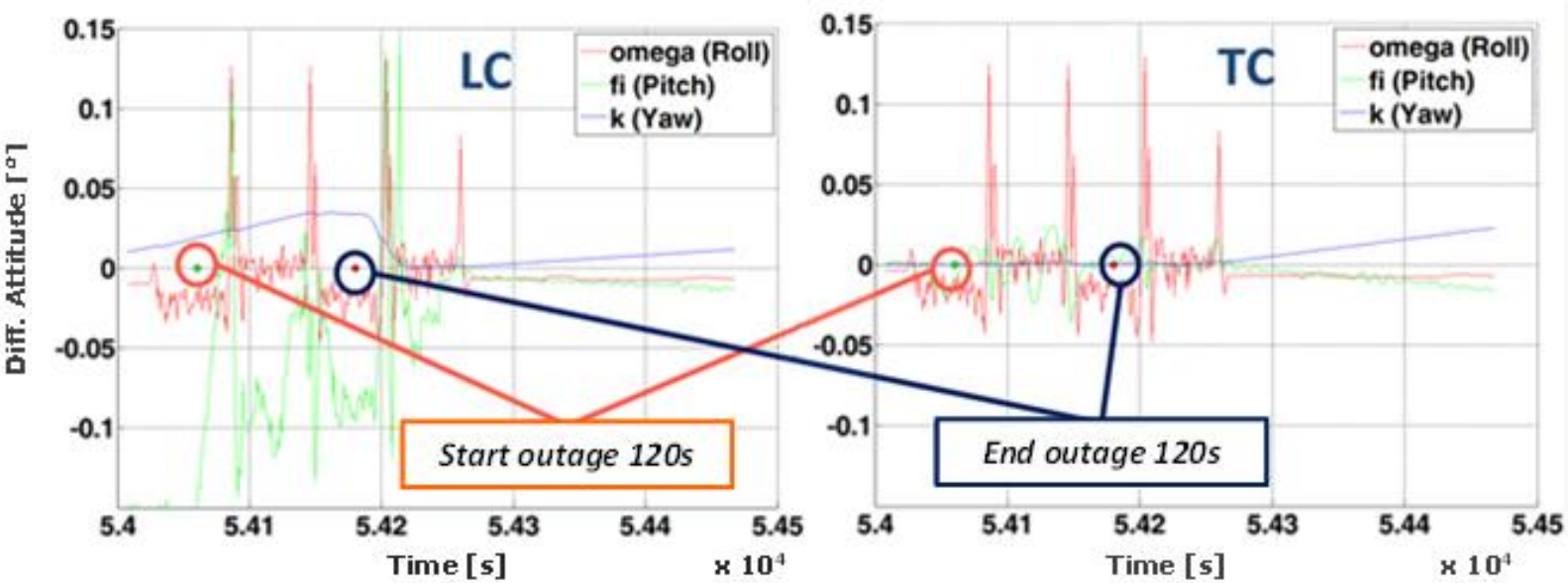
a) LC processing

b) TC processing

Each outage enables driving (considering a speed of 50km/h) along 450 m, 900 m and 1800 m respectively with GNSS positioning, which are comparable distances with the length or multiple of the racetrack

POSITIONING RESULTS: ATTITUDE

We have also computed the angular error during outages
Reference attitude: attitude without outages



a) LC processing

b) TC processing

Angular comparison according to: $\left[R_{ERR}^{NF}\right] = \left(\left[R_{NF(Tr)}^{BF}\right]\right)^{T}\left[R_{NF(Outages)}^{BF}\right]$

POSITIONING RESULTS

Outage length [s]	Processing strategy	Average Δ2D ± σ [m]	Average Δh ± σ [m]
30	LC	0.06 ± 0.06	-0.07 ± 0.02
	TC	0.03 ± 0.02	-0.06 ± 0.02
60	LC	1.48 ± 1.39	-0.13 ± 0.08
	TC	0.14 ± 0.13	-0.03 ± 0.04
120	LC	6.12 ± 5.67	0.20 ± 0.25
	TC	0.91 ± 0.56	0.03 ± 0.08

We can see the averages and the sigma of these errors, for planimetry, altimetry and the maximum error for the angles

Only the pitch and yaw are better with TC approach

Maximum angular residual during outage 120s	Processing strategy	Roll ω	Pitch ρ	Yaw K
	LC	<0.13°	<0.15°	<0.03°
	TC	<0.13°	0.02°	< 0.01°

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CONCLUSIONS & REMARKS

- It is fundamental to make an accurate calibration before the survey
- These tests are a useful methodology to evaluate the real accuracy of these sensors
- This system allows also to obtain a RT results but the best accuracy is always obtained in post processing with TC treatment;
- from a planimetric point of view, using the available instruments and cartography purposes, there may be a lack of data of 60 s (for decimeter accuracy & 1/1000 scale);
- for road cadastral applications, this range may also be stretched to about two minutes (for 1 m accuracy).

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