2014 ForestSAT conference, 4-7 November, Riva del Garda (Italy)

TARGETSTARS: an accuracy performance evaluation system for GNSS technologies in forest environments

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Introduction

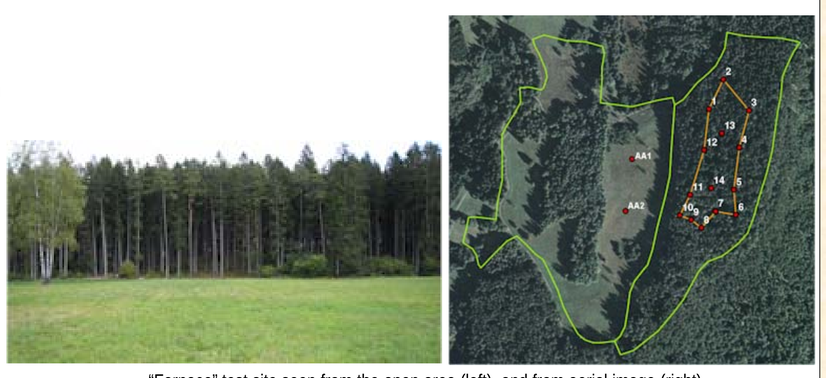
The increasing prevalence of satellite positioning technologies in forestry ground surveys requires verification criteria and reliability certification for positioning performed under tree canopy. The recent progress in classification and estimation techniques which make use of remote sensed data (multi- and hyper -spectral images, LiDAR etc...) often calibrated with "ground truth" plots, represents a new challenge in GNSS accuracy targets with respect to those reached in a recent past.

Performances of precision claimed by the manufacturers, referred to ideal operating conditions (full visibility of satellite constellations, absence of trees or other obstacles), do not fully correspond to the actual usage of the receivers in forest environments.

The collaboration between the Italian National Forest Service and the CRA-MPF under the TARGETSTARS project has led, after a preliminary study, to the creation of a network of test areas, under different forest cover, and to a standard protocol to test GNSS devices.

Three test sites have so far been established, representing some of the most common forest types (structure and species composition) of Italy: Fornace (Trentino, mixed stand of alpine coniferous), Piancancelli (Emilia-Romagna, beech coppice evolving to high forest), Feudozzo (Abruzzo, mixed oak stand). Three other sites are planned in North-West and in Center-Southern Italy, in order to complete the site network. In each test area, a canopy-free test point is available too, in order to compare the accuracy of the same receiver with or without tree canopy. Each test site is about 1.5-2 hectars large, and has 12-16 vertices settled with high accuracy coordinates (RMSE < 5 cm). Vertices are 20 to 80 meters far from each other. They are so distributed to cover all the stand variability in terms of stem density and canopy coverage.

TARGETSTARS Test site network



"Fornace" test site seen from the open area (left), and from aerial image (right)

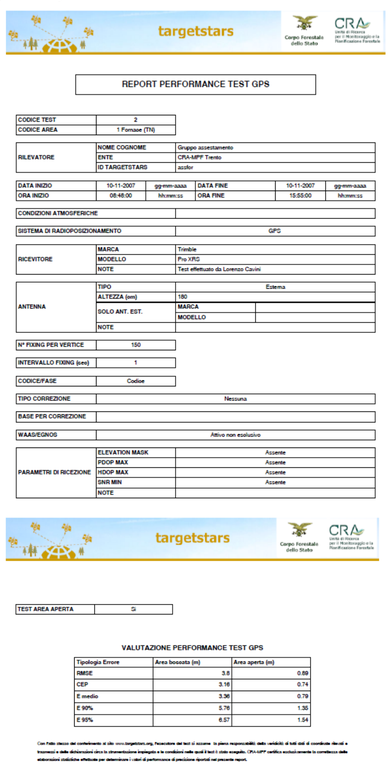
Concrete monument stone with its wood stake (left), wood plate with vertex data (center), and informative showcase (right)

Materials and methods

A website (www.targetstars.org) manages all the procedures and processing tools necessary to elaborate the accuracy performances of GNSS receivers used in one of the test areas.

Registered users can freely download the instructions to perform the test, send (via the Internet) the data recorded in the field and receive the results of their tests in real time. Such results are expressed as statistical error parameters (RMSE and others) with respect to the distance from "true" position of all the vertices of the same test area.

Since all tests are registered in a common database, some queries allowed to summarize the test results by: a) receiver category; b) number of positions averaged; c) differential correction.



REPORT PERFORMANCE TEST GPS

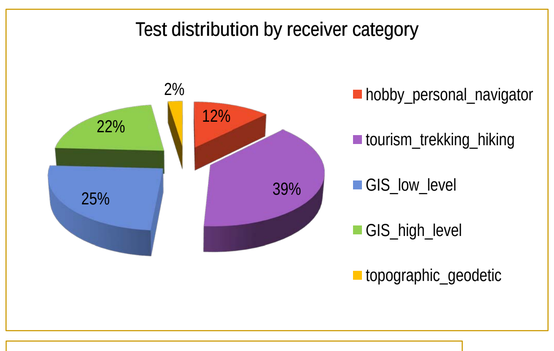
CODICE TEST	2					
CODICE AREA	1 Fornace (TN)					
RILEVATORE	NOME COGNOME	Gruppo assestamento				
	ENTE	CRA-MPF Trento				
	ID TARGETSTARS	ascifor				
DATA INIZIO	10-11-2007	gg-mm-aaaa	DATA FINE	10-11-2007	gg-mm-aaaa	
ORA INIZIO	06:48:00	hh:mm:ss	ORA FINE	15:55:00	hh:mm:ss	
CONDIZIONI ATMOSFERICHE						
SISTEMA DI RADIOPOSIZIONAMENTO	GPS					
RICEVITORE	MARCA	Trimble				
	MODELLO	Pro XRS				
	NOTE	Test effettuato da Lorenzo Cavini				
ANTENNA	TIPO	Esterna				
	ALTEZZA (cm)	180				
	SOLO ANT. EST.	MARCA				
		MODELLO				
	NOTE					
N° FIXING PER VERTICE	150					
INTERVALLO FIXING (sec)	1					
CODICE/FASE	Codice					
TIPO CORREZIONE	Nessuna					
BASE PER CORREZIONE						
WAAS/EGNOS	Attivo non esclusivo					
PARAMETRI DI RICEZIONE	ELEVATION MASK	Assente				
	PDOP MAX	Assente				
	HDOP MAX	Assente				
	SNR MIN	Assente				
	NOTE					

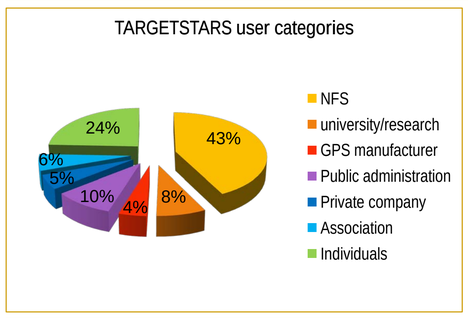
TEST AREA APERTA	Si

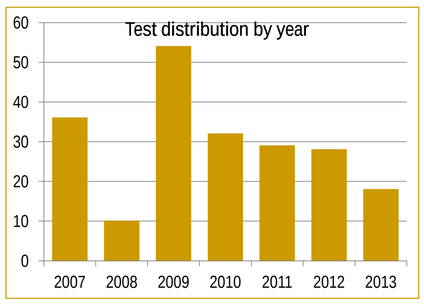
VALUTAZIONE PERFORMANCE TEST GPS

Tipologia Errore	Area bosscata (m)	Area aperta (m)
RMSE	3.8	0.89
CEP	3.18	0.74
E medio	3.36	0.78
E 90%	5.76	1.36
E 95%	6.57	1.54

Example of a test report produced (in PDF format) by the TARGETSTARS web database







Results

At the end of year 2013, the Targetstars web-database had accounted for 207 tests, carried out by about 120 logged users.

27 tests were carried out using GPS/Glonass receivers; with regard to differential correction, 176 tests were carried out without correction, 25 tests were carried out with PP-DGPS, and only 6 with RT-DGPS.107 tests were declared to be done without EGNOS activation, but most receivers usually implement this possibility as a default, and thus we think that many users supplied wrong information on that.

Main statistics on positioning accuracy (RMSE, m) by receiver category and by number of averaged positions, under tree canopy.

Receiver category	Number of aver. positions	n. obs.	mean	min	max	ST. dev.
Hobby	1	9	14,70	5,39	31,32	8,40
	10	6	9,31	4,56	15,09	4,05
	50	6	10,76	7,56	15,34	2,79
	150	5	9,52	7,34	12,01	1,78
Tourism	1	6	10,01	4,03	18,81	5,23
	10	10	11,55	6,25	28,22	6,73
	50	44	6,68	3,61	16,79	2,75
	150	20	5,76	2,41	10,90	2,20
GIS low level	1	12	12,93	5,15	29,49	7,65
	10	10	12,39	4,19	22,72	7,14
	50	16	8,43	4,01	20,63	4,21
	150	13	7,42	2,86	14,69	3,44
GIS high level	1	6	5,84	2,27	7,59	2,27
	10	13	13,00	2,32	56,86*	19,63
	50	19	3,71	1,99	7,50	1,41
	150	7	4,00	2,60	8,36	1,98
Geodetic	50	2	1,93	1,91	1,94	---

Main statistics on positioning accuracy (RMSE, m) with respect to differential correction, under tree canopy (GIS-low-level receivers).

Receiver category	Number of aver. positions	n. obs.	mean	min	max	ST. dev.
UNCOR	1	8	13,52	5,15	29,49	8,40
	10	7	10,86	4,19	22,72	7,22
	50	12	7,74	4,01	20,63	4,50
	150	8	7,10	2,86	14,69	4,03
DGPS	1	3	13,76	5,87	17,94	6,84
	10	3	15,96	8,13	20,23	6,79
	50	4	10,52	6,64	12,20	2,60
	150	4	8,18	5,47	10,76	2,91

Main statistics on positioning accuracy (RMSE, m) with respect to differential correction, under tree canopy (GIS-high-level receivers).

Receiver category	Number of aver. positions	n. obs.	mean	min	max	ST. dev.
UNCOR	1	4	5,95	2,27	7,34	2,45
	10	11	14,64	2,32	56,86*	21,06
	50	13	3,93	2,49	7,50	1,53
	150	5	4,36	2,60	8,36	2,29
DGPS	1	2	5,64	3,69	7,59	2,76
	10	2	4,00	3,42	4,57	0,81
	50	6	3,24	1,99	4,90	1,03
	150	2	3,10	2,85	3,34	0,35

*This value was probably an outlier due to some kind of mistake during test performing.

Good results are achieved by tourism receivers (especially in relation to their costs), although they don't allow differential correction or other parameter control.

High-grade GIS receivers doesn't seem to be greatly conditioned by the number of averaged positions.

Differential correction does not supply clear benefits in wooded areas, probably because its effects are masked by more severe error sources (e.g., multipath).

Geodetic grade receivers confirm to be not reliable to operate under tree cover, but the tests for this category are so far very few.

All tests in adiacent open areas (which could not be reported for room reasons) confirm the advantage to perform, when possible, offset positioning in open- or low-cover areas close to the target.

Conclusions

Targetstars is an example of "experiment" shared by many users: for this reason, performance results have sometimes to be taken with caution.

The site network and the survey protocols are ready to current and future developments of GNSS, like GLONASS, GALILEO and other systems.

GPS testing is a work in progress and requires continuous update: besides the need to test new models of receivers, the concept of performance itself changes over the time and over the purposes.

Targestars test sites have so far been used for education and training activities too, involving students and professionals not only in GNSS techniques, but also in using laser range-finders, electronic compasses and other forest measurement devices.

Targestars project will continue, moving from **point positioning** accuracy to **line** and **area positioning** accuracy, with respect to their two components (position and size).

References

- USDA Forest Service GPS homepage. URL http://www.fs.fed.us/database/gps/index.htm. [on line 03/11/2014]
- POMPEI E., CLEMENTEL F., COLLE G., FLORIS A., GALVAGNI D., LIBRANDI I., MARZULLO L., PICCOLI D., SCRINZI G., 2009 - Sistema di valutazione e certificazione delle performance di precisione delle tecnologie di rilievo satellitare in dotazione al Corpo Forestale dello Stato in presenza di copertura forestale. Atti 13a Conferenza Nazionale ASITA, 1 – 4 dicembre 2009, Fiera del Levante Bari, pp. 1627-1632.
- COLLE G., FLORIS A., SCRINZI G., TABACCHI G., CAVINI L., 2007. The Italian National Forest Inventory: geographical and positioning aspects in relation to the different phases of the project. In: Proceedings, 8th annual forest inventory and analysis symposium; 2006 October 16-19; Monterey, CA, USA.
- SCRINZI G., FLORIS A., PICCI M., 2000 - GPS and forest inventories: accurate positioning and finding of sample points. Comunicazioni di Ricerca ISAFA 99/1, Trento, 1-11.