Analysis of the advantage of using the SiRFStarIII architecture for navigational purposes in urban areas

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Abstract. *In the last few years the market of navigational devices experienced it's biggest boom – their every-day presense was never bigger. Meanwhile, because of a higher degree of use of navigational devices in urban ares as the engineering offensive on them some standard GPS problems are present – weak signal from satellites which leads to smaller accuracy and long Time To First Fix (TTFF). For a better situation, the company SiRF Technology Holdings, Inc. made a new chipset SiRFStarIII which accent is on higher sensitivity, short TTFF and represents the newest achievement in satellite navigation. This paper shows the analysis of the advantage of using the chipset SiRFStarIII in urban areas through few practical tests on the area of The City of Zagreb, Croatia*

Keywords: *GNSS, GPS, navigation, microcontroler, SiRFStarIII.*

1. Introduction

From the beginning of the civilisation and life in general, the task of transport represented a very important component of every individual and service. This important life segment couldn't be imagined without the use of an old skill and activity – navigation which from its beginning represented a brand and an activity reserved for contemporary scholastic individuals. Exactly the navigation on the sea provided the finding of America and new routes. Today's navigation on its fundamental philosophy isn't much different from it's beginning, the novelty represents the huge number of users because of a big rate of small costs for navigational systems and user-friendly approach which must be thanked to the market and the ability of their appliance on everyday's life and a big number of activities.

Today, the navigation of 21th century can't be imagined without the usage of the components of the set called *Global Navigation Satellite System* (GNSS). GNSS is a term used for satellite navigational systems which purpose is to provide the geographic position on a global basis. In the time of this paper's writing the only fully functional GNSS is *Navigation Satellite Timing And Ranging Global Positioning System* (NAVSTAR GPS) developed by the U.S. Department of Defense[1] which presents almost a global property. In the phase for the fully operation is the system *Global'naya Navigatsionnaya Sputnikovaya Sistema* (GLONASS) which is currently under the duty of the Russian Space Forces[2], and the Global navigational system Galileo which is under the

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[1] United States Department of Defense; (http://www.defenselink.mil/)
[2] Russian Space Force (http://www.mil.ru/eng/1862/12068/12088/12224/index.shtml)

development of the European Space Agency[3] (ESA) and the European Union (EU). GNSS presents a real revolution in all parts of navigation because of its fast and accurate positioning service which must be thanked to the U.S. goverment which opened its use to all, not just U.S. citizens, but to the whole world, and the removal of the **S**elective **A**vailability (SA) system which deliberately added an error on the final result because of military interests. The revolution reflected on a rapid development of new navigational devices for civil purposes. Thanks to the above mentioned factors and increased number of manufacturers, the number of users of navigational systems today is bigger than ever and in developed countries it represents a component of everyday life. The Figure 1 shows a today's representative navigational device for civil purposes.

Figure 1.
Navigational device RoadMate 2200T from the manufacturer ''Magellan''; (URL-2)

2. Navigational devices and users clasification

The determination of position coordinates is one of the fundamental tasks of Geodesy. There are two purposes of the position determination in Geodesy: the purpose of positioning and the purpose of navigation. The term navigation means to mantain a constant heading over a instantaneously object position determination, i.e. determination of route of an object motion. Positioning is used for determination of an object coordinates. It is important to mention that navigation is just a special case of positioning and their distinction is hard to define. Positioning delivers more accurate coordinates, but the process is longer than that of navigational purposes where an accurate position is not essential. With these purposes the GNSS unit development was divided through two markets:

- units for the purpose of positioning (mostly in geomatics) and
- units for navigational purposes

The first mentioned market is smaller than the navigation market, but the average price of the equipment is few dozen times higher than the average price of the navigational equipment. Maybe proportionally to the price, the standard deviation of the position derived from the positioning units is many times less than the position derived from navigational units. In this paper, as the introduction and title partialy showed, the emphasis is on the navigational purposes.

The majority of users from the mentioned group is of civil character and is mostly consisted of users of transport vehicles, sailors, users for personal navigation (orientation in cities, nature – trekking, etc.).

3. Problems in urban areas

In the time of writing this article almost all users are using the american GPS and its compactible devices. A very large number of navigational units is used in urban areas where the device-satellite Line of Sight (LoS) as the fundamental requirement for quality transmission and accurate positioning is interrupted because of urban barriers – high constructions, vegetation and a high concentration of EM traffic and noise. Of course, in the case of transport users the vehicle barrier (e.g. window with anti-UV protection) must also be considered.

With the reduced number of available GPS satellites and weak signal from them the final product – the geographic position of the user, with considering the device capabilities, is relatively innacurate and the continuity of fix isn't long and confident. Multi-pathing, as a unwished efect, must also be considered, but for the goal of this article it will not be mentioned in the following text.

4. Microcontroler SiRFStarIII and its advantages

The central part of every GNSS receiver is the microcontroler. Microcontroler is, shortly, a computer-on-chip (microcontroller is not a microprocessor which is its part). In GPS receivers, microcontroler is the unit responsible for the GPS signal interpretation and processing so a special care must be directed into the production of the GPS receiver's microcontroler. Microcontrolers are producted by just few manufacturers in the world which are selling them to the manufacturers of the navigational equipment. Accordingly, today two GPS receivers with the same microcontroller can be found.
SiRFstarIII is the newest GPS microcontroller which was manufactured by the very popular company SiRF Technology Holdings, Inc.[4] from California, USA. This chip represents the biggest achievement in this area yet. SiRFStarIII is special for its high sensitivity (-159dBm), lower Time To First Fix when the receiver is turned on (or lost the fix) and a higher number of correlators (200k) of its concurents. This solution was quickly adopted by the lead manufacturers in the navigational equipment (e.g. Lowrance, TomTom, Garmin and Magellan) and started to implement it in their products which led to today's situation where SiRFStarIII is almost a standard for that very important part of a GPS receiver.

5. Analysis of the microcontroler SiRFStarIII

To prove these facts an analysis of the potential advantage of using the SiRFStarIII chipset has been made in the parts where most of the navigational equipment is used and where most problems are present – in urban areas. The definitive product of all GNSS receivers – geographic position has been analysed.

5.1 Anylised receivers

The advantage of using the SiRFStarIII chipset was determinated from the results of the relative comparing

[3] European Space Agency (http://www.esa.int/)
[4] http://www.sirf.com

with an old chipset. So, it was essential to find two very similar GPS receivers so the analysis could concentrate on microcontrollers. The best choice were the Garmin devices GPSMap 60CS and GPSMap 60CSx (lend from the company Navigo Sistem d.o.o.) because 60CSx is just a continuation of the very successful receiver 60CS. The units are physically equal, but the microcontroller is different: 60CS uses the Garmin's old generation 12-channel chipset and 60CSx the new SiRFStarIII which makes these devices an optimal choice for this analysis.

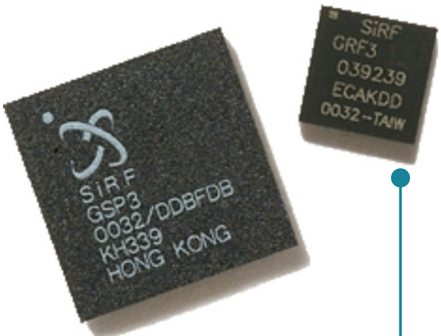

Figure 4-1.
SiRFStarIII architecture; (URL-2)

5.2 Analysis description

The analysis of above mentioned GPS receivers consists of two parts:

- analysis of GPS units for navigational purposes
- analysis of GPS units for positioning purposes

Although the units are manufactured for the primary purpose of navigation, the positioning analysis is also made because of navigation's special case of positioning. The receivers were tested with disabled and then enabled EGNOS[5] option.

5.3 Analysis and interpretation of navigational solutions

For the navigational test route three representative parts of Zagreb, Croatia were taken into account: Klaićeva street, Tito's square and Masarykova street. The devices were configured for the spacetime position (latitude and longitude in decimal degrees, height in metres) registration every one second in ITRF2000 frame on WGS84 ellipsoid and time in UTC[6] system.

Figure 5-1 i 5-1a. City walk in mentioned routes with receivers in the backpack

The test was executed on March 30 in 2007, between 8:30am and 9:30am, with a average city walt (figure 5-1) in mentioned streets. The GPS devices were in the backpack, put closely together (figure 5-1a).

From the position gathered from the receivers, the routes were visualized on the Zagreb digital ortophoto – two paths for every receiver (with and without enabled EGNOS) with past coordinate transformation from ITRF2000 to HDKS (Croatian State Geodetic Coordinate System) 5. zone Gauss-Krueger's projection with the official transformation program Dat_Abmo from the Croatian State Geodetic Administration.

From the Figure 5-2 it is possible to conclude that both devices had a stable position fix in the Klaićeva street, what wasn't expected because of the street's architecture and near high buildings what implicated on a possible outage. On Tito's square, because of a very good LoS, it was expected that both devices would not

[5] EGNOS is European Geostationary Navigation Overlay Service, DGPS system for the distribution of corrections through a geostationar satellite whose primary purpose is to enhance the final product – geographic coordinates of the device
[6] Universal Time Coordinated

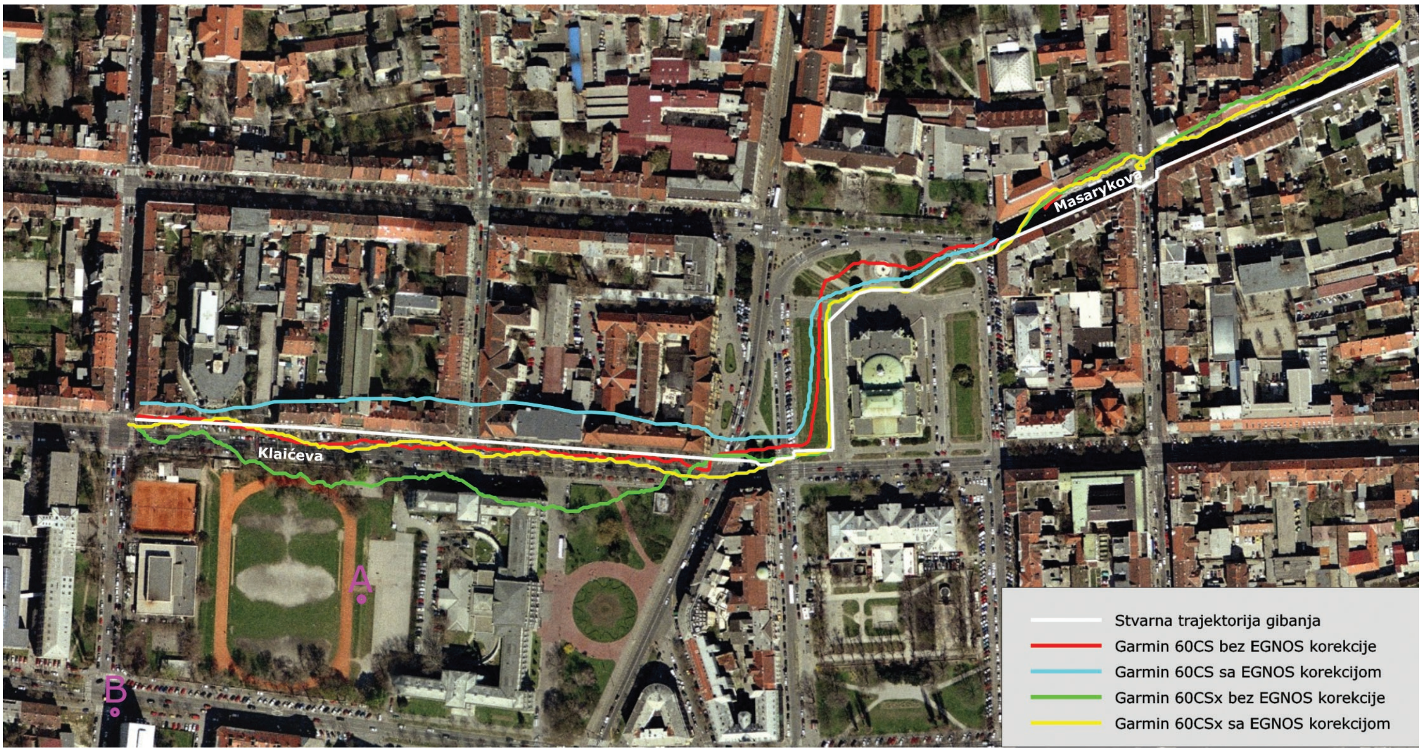

Figure 5-2. Motion paths of the devices

have any problems with the satellite fix. The tricky part was Masarykova street with its architecture (less large then Klaićeva) and with its high buildings. In this part of the test the SiRFStarIII technology showed its advantages – Garmin GPSMap 60CS recorded a position fix break soon as entered in the street. In the middle of the street the receiver obtained a short fix, but with high deviation from the real path. Instead, the Garmin GPSMap 60CSx had a constant fix and was giving a relatively accurate position. With that, the title of this paper is justified.

It is important to mention that the enableation of the EGNOS differential correction of the position is affecting the quality of the position, not the quality of satellite signal in urban areas.

5.4 Analysis and interpretation of position solutions

After the proof of the advantage of the SiRFStarIII technology in urban areas it was interesting to explore this thesis in a absolute positioning case. As tests points, two points are taken: the first (point A) in the high school field with excellent LoS to satellites, stabilised with a concrete pole 20x20x50cm (figure 5-3) and a point from the GPS network of the City of Zagreb (point B) with a bad LoS to the sky. To both points the coordinates in HDKS are known. The approach was

Figure 5-3. Point A

Figure 5-4. Point B

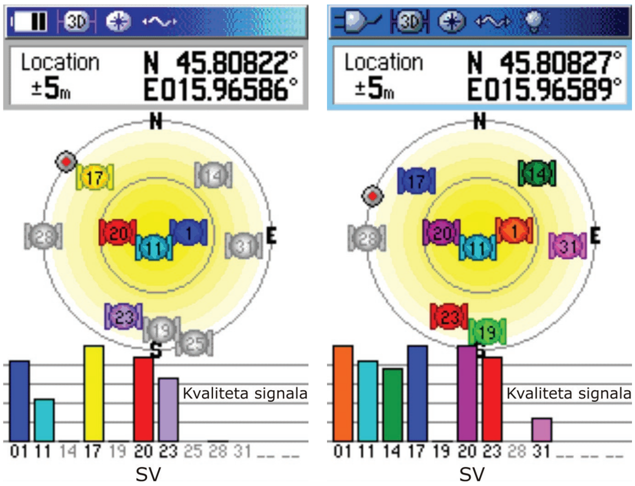

Figure 5-5. Receiver screenshots on the point A without the EGNOS correction. 60CS is on the left, 60CSx right

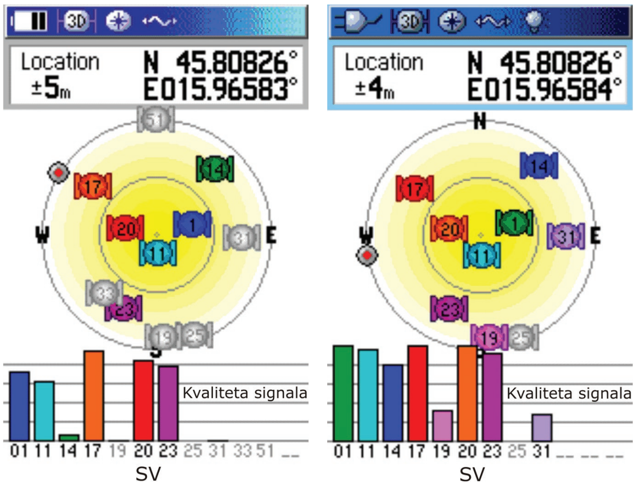

Figure 5-6. Receiver screenshots on the point A with the EGNOS correction. 60CS is on the left, 60CSx right

very similar to the navigational test where both devices where very near, with the registration interval of one second and with EGNOS disabled and then enabled.

Point A

In the time of surveying the point A, a screenshot of both devices was made so the number of satellites which are recorded by both satellites could be registered. This was made in two cases – with disabled EGNOS correction and then enabled. In the first case (w/o EGNOS) the ratio of registered satellites was 7:5 in benefit to the 60CSx receiver (figure 5-5). In the second survey (w/ EGNOS) the receiver 60CSx had the advantage of 8:6 (figure 5-6).

In the Tables 5-1 and 5-2 a statistical analysis of coordinate differences and distance from the real value and aquired value is given. From the statistical analysis it is visible that the value of the standard deviation is smaller in the 60CSx receiver analysis which again implicates the advantage of the SiRFStarIII technology, despite the very good LoS on the point A. Because of the open sky of the point A the effect of the EGNOS correction can be considered. In the case of the 60CSx device the standard deviation of dy, dx and D elements are decreasing comparing to values when EGNOS isn't enabled. In the case of 60CS this, because of unknown reasons, is not the case.

Point B

The point A positioning principe was also applied for the point A. With disabled EGNOS correction (figure 5-7) the ratio of registered satellites was 9:4 in the behalf of the 60CSx. With enabled EGNOS (figure 5-8) the ratio was 7:3, also in the advantage of the 60CSx.

As the LoS of the point B was bad, the fact that with the enabled EGNOS correction the receiver 60CS showed an extremely inaccurate position (±61m, figure 10 left), this isn't to concern, because of the lack of SiRFStarIII technology.

It is interesting to analyse gained statistical positioning data on the point B. From the Table 5-3 it is visible that the values of statistical components dy, dx, D in the case of the enabled EGNOS correction for the Garmin GPSMap 60CS receiver (pink colour) are very beyond acceptable values. In fact, in this part of the analysis a complete disruption occured because of an insufficient number of satellites (minimal 3 satellites is required) so the receiver wasn't recording any current position data. Statistics were made on the basis of the first fix to the time of the disruption.

Garmin GPSMap 60CSx (Table 5-4) didn't experience these problems and in both cases was fully registering its position and prooved the advantage of its chipset in urban areas. Unfortunatelly, as a result of the very bad LoS on the point B, the EGNOS correction

Table 5-1. Elements dy, dx i D statistics for the point A (Garmin GPSMap 60CS) in metres [m]

Garmin GPSMap 60CS - Točka A	dy bez EGNOS	dy EGNOS	dx bez EGNOS	dx EGNOS	D bez EGNOS	D EGNOS
Max	-0,931	24,354	2,841	39,673	6,904	41,398
Min	-6,319	-2,487	-2,784	1,708	1,962	1,962
Sredina	-1,580	-0,785	1,499	2,309	2,566	2,600
St.dev.	1,171	1,577	1,174	3,669	0,951	3,891

Table 5-2. Elements dy, dx i D statistics for the point B (Garmin GPSMap 60CSx) in metres [m]

Garmin GPSMap 60CSx - Točka A	dy bez EGNOS	dy EGNOS	dx bez EGNOS	dx EGNOS	D bez EGNOS	D EGNOS
Max	2,942	1,401	3,988	3,980	4,531	4,210
Min	0,595	-0,959	1,746	1,755	1,854	2,246
Sredina	1,766	1,315	2,177	2,507	2,858	2,869
St.dev.	0,655	0,307	0,676	0,636	0,759	0,531

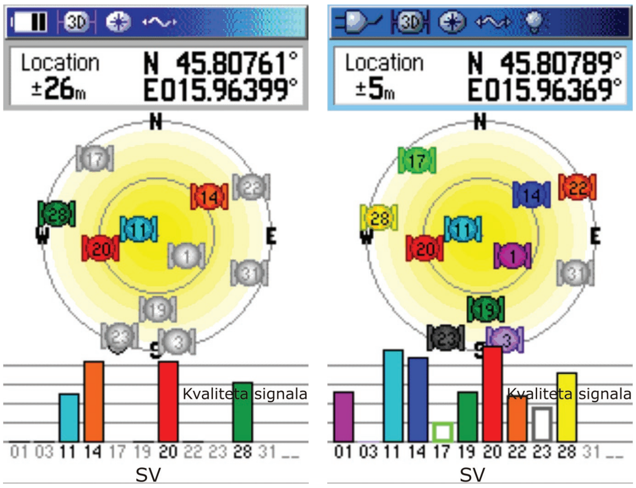

Figure 5-7. Point A screenshot of 60CS (left) and 60CSx (right)

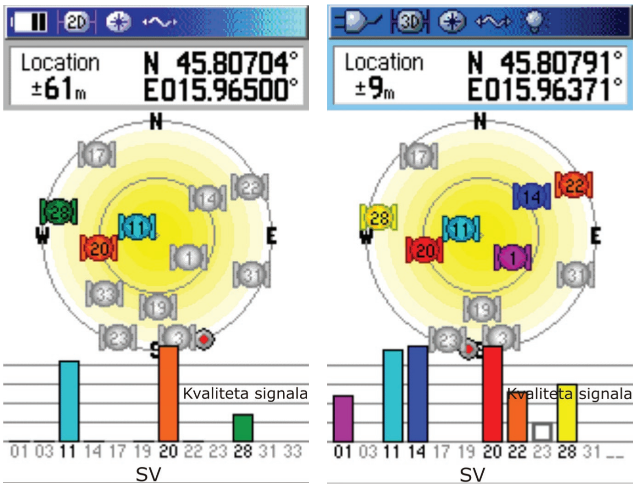

Figure 5-8. Point B screenshot of 60CS (left) and 60CSx (right)

couldn't correct the position.

At the end of the analysis a histogram of standard deviations of elements dy, dx and D of the whole analysis is included for an easy interpreation, conception, comparing and image of the results gained.

6. Conclusion

Based on this research it is possible to conclude that SiRFStarIII technology in devices made for navigation is a big step forward in the quality of satellite signal reception comparing other devices without the mentioned architecture. According to the meaning of absolute positioning, i.e. it's special case – navigation, the gained accuracy of the position is acceptable and sometimes is very "optimistic". EGNOS correction is significat only in a convenient area of quality LoS so its inclusion in urban areas isn't essential.

Authors would like to mark that above mentioned results are connected only with this research and any further conclusion and reference from this paper in the way of decision making in the receivers buying is not advisable.

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Picture from the article headline: Garmin GPSMap 60CS and 60CSx devices at point A.

Garmin GPSMap 60CS - Točka B

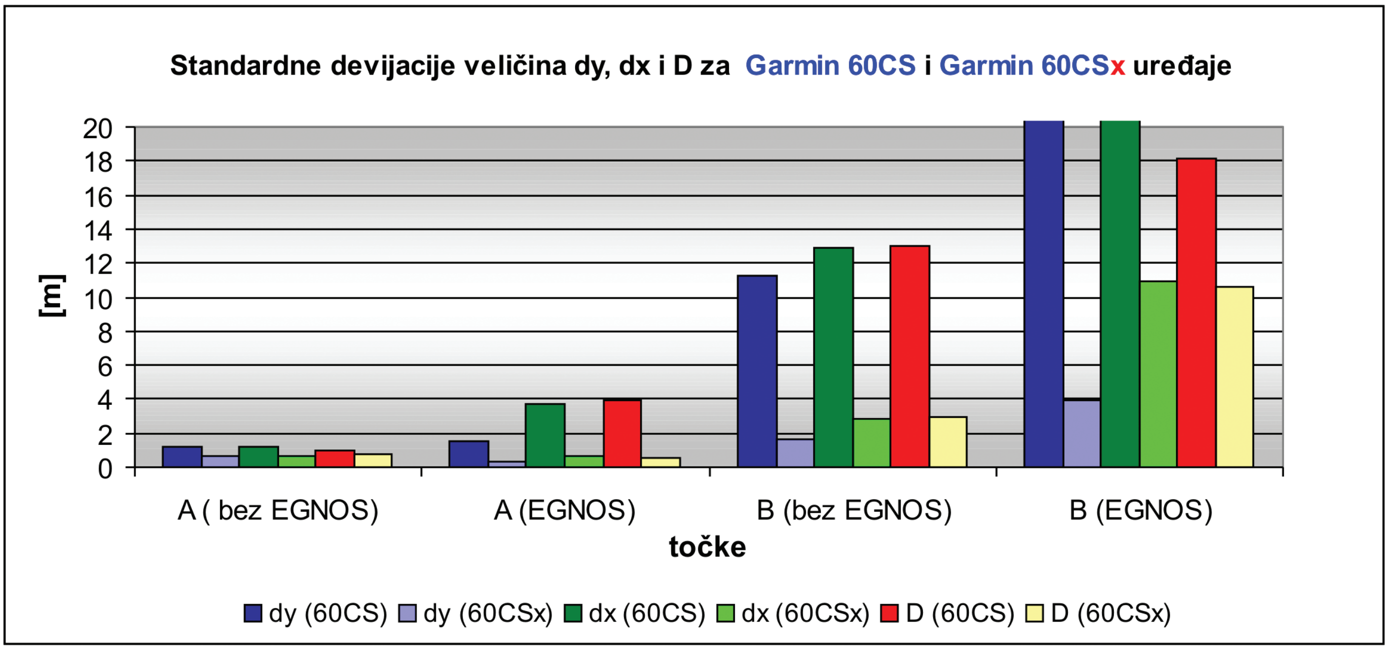
	dy bez EGNOS	dy EGNOS	dx bez EGNOS	dx EGNOS	D bez EGNOS	D EGNOS
Max	102,906	135,716	12,021	142,460	104,249	165,140
Min	-6,269	-65,367	-47,926	-94,087	1,920	101,112
Sredina	-1,025	47,914	-0,279	-2,631	11,150	123,990
St.dev.	11,273	73,765	12,873	90,226	13,014	18,090

Table 5-3. Elements dy, dx i D statistics for the point B (Garmin GPSMap 60CS) in metres

Garmin GPSMap 60CSx - Točka B

	dy bez EGNOS	dy EGNOS	dx bez EGNOS	dx EGNOS	D bez EGNOS	D EGNOS
Max	1,586	5,579	19,766	38,591	21,594	41,177
Min	-8,694	-14,362	-1,240	-5,657	0,166	0,885
Sredina	-0,874	-6,050	4,182	14,940	4,482	16,771
St.dev.	1,588	3,921	2,871	10,897	2,988	10,612

Table 5-4. Elements dy, dx i D statistics for the point B (Garmin GPSMap 60CSx) in metres [m]



Histogram 1. Standard deviations of the elements dy, dx i D of the analysis on both points showed in metres [m]