TRANSNAV International Journal on Marine Navigation and Safety of Sea Transportation
Volume 3 Number 3 September 2009

Positioning Using GPS and GLONASS Systems

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ABSTRACT: This paper presents an experiment involving the processing of observations using the GPS and GPS/GLONASS systems performed at the BOGO, BOGI, and JOZ2 IGS stations. Due to the small number of GLONASS satellites, the authors failed to receive any significant improvement in positioning accuracy using GPS and GLONASS observations jointly.

1 INTRODUCTION

The slogan "GPS/GLONASS satellite measurements" has become popular recently. Judging by news provided by the press, including Inside GNSS, one may get the impression that the GLONASS system is making its comeback and the number of active satellites in the system is steadily growing. This was the reason for an increase in our interest in the joint utilisation of both navigation systems in practice, especially after the correction of the Russian reference system with respect to the ITRF system with only a centimetre shift parameters (September 2007). What remains is the problem of differences in the time scale, but nothing seems to demonstrate that this is particularly significant. So, what is it we did in order to confirm the impact of observations of GLONASS satellites on the accuracy of GNSS positioning? We conducted an experiment for which we selected monthly data (September 2007) from the BOGO, BOGI, and JOZ2 stations (BOGO and BOGI are very close to each other while JOZ2 is at a distance of approximately 42 km). The observations were processed using Trimble Total Control software as the network of selected points is not vast. The network of vectors connecting the specified points was designated using two alternatives. The first only used GPS observations while the second applied both systems – GPS and GLONASS. The quantity and configuration of GLONASS satellites makes impossible the independent analysis of observations exclusively from the GLONASS system. In spite of the placement of successive GLONASS system satellites in orbit, the number of active SVS has not changed as of this day. The Russian's efforts are concentrated on replacing the old type satellites with new ones.

2 THE EXPERIMENT

What was done was a comparison of vector determinations for the GPS and GPS/GLONASS data. Two types of vectors were considered: long (forty-two kilometre) and short (one hundred metre) ones. The vector components, long and short, of the determinations from daily cycles were characterised by a mean error of 2 mm, and nothing seems to suggest any change in the values of the vector components or their accuracy characteristics in terms of both solutions conducted using data exclusively from GPS and utilising observations made using the two systems. Figure no. 1 presents changes in the "long" vector components calculated for daily observation cycles. The equalised coordinate values for the three points earmarked for the experiment for solutions using only GPS data and those using both systems gave identical results with an accuracy of result presentation.

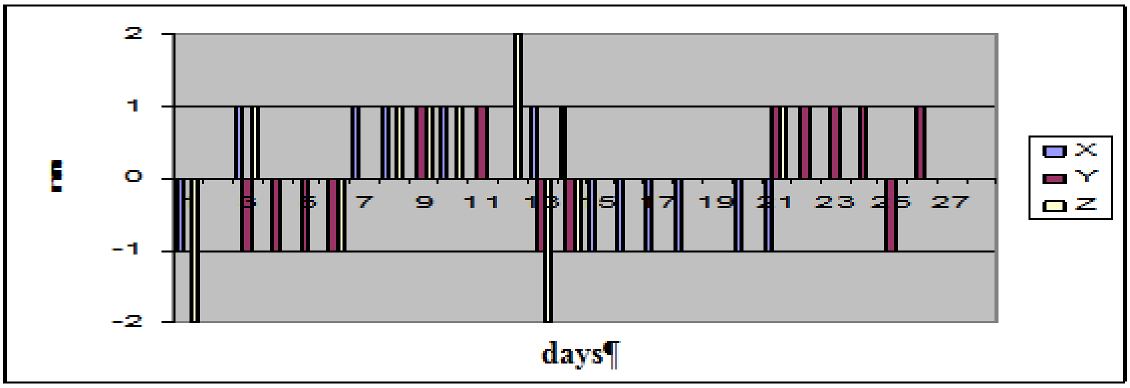

Figure 1. Changes in the BOGI-JOZ2 vector components in a 3D system

The lack of any discernable difference in results for the daily solutions induced us to conduct an analysis of DOP coefficients, making possible an assessment of the “strength” of the solutions in relation to satellite numbers and configurations.

3 GDOP (GEOMETRICAL COEFFICIENT)

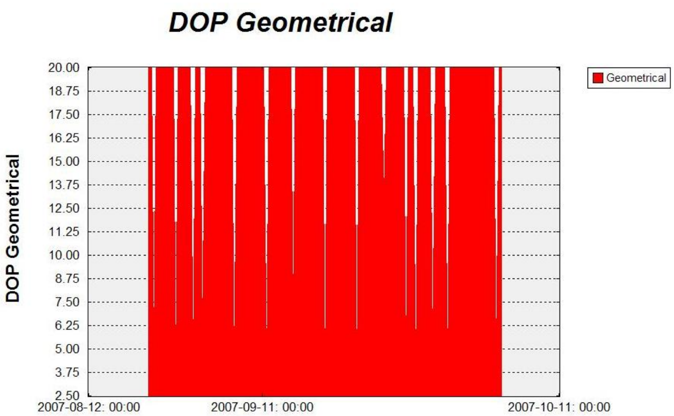

Figure 2. GDOP for the GLONASS system

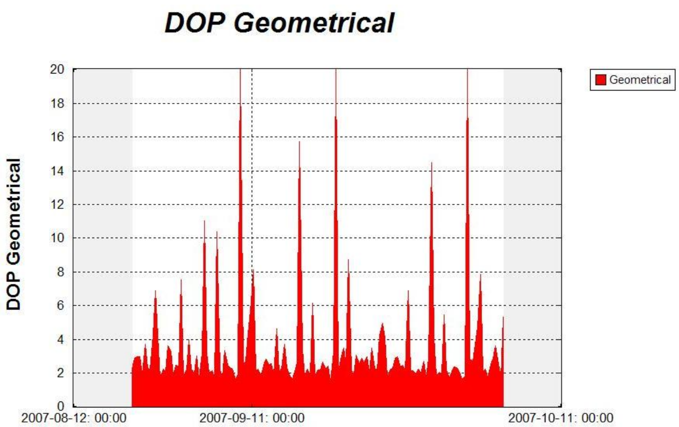

Figure 3. GDOP for the GPS system

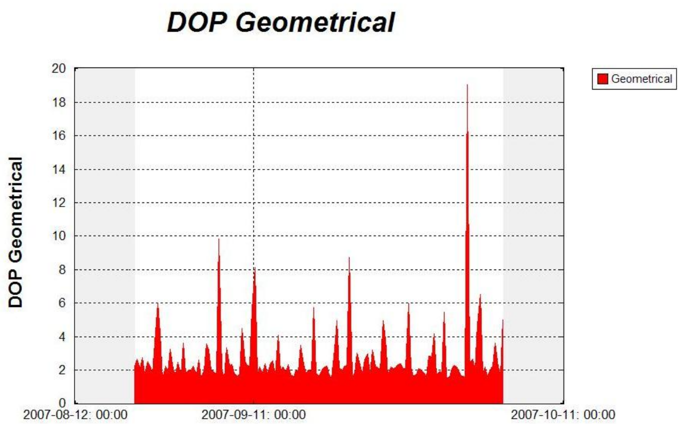

Figure 4. The common GDOP for GPS/ GLONASS systems

4 HDOP (2D SOLUTIONS) AND VDOP (HEIGHT)

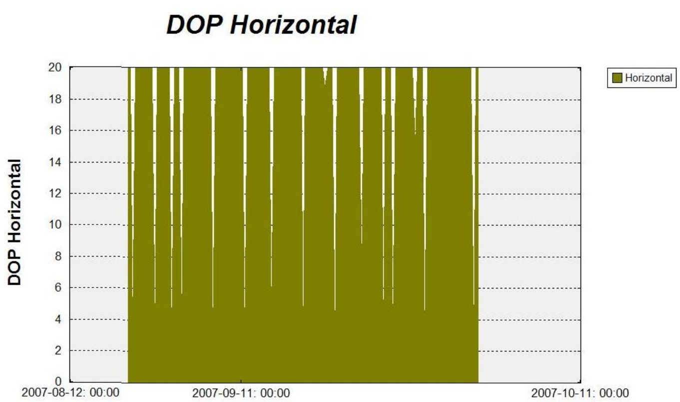

Figure 5. HDOP coefficient for the GLONASS system

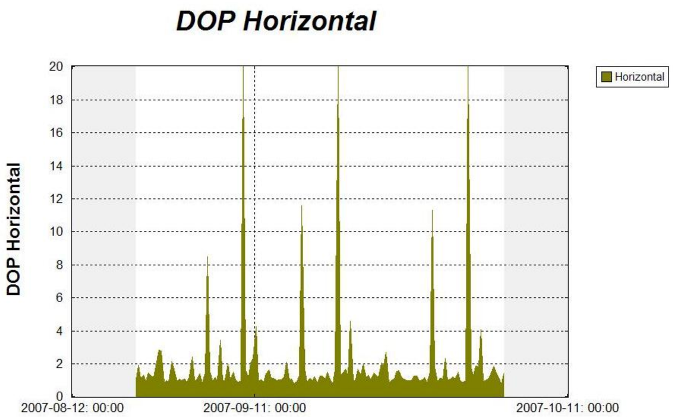

Figure 6. HDOP coefficient for the GPS system

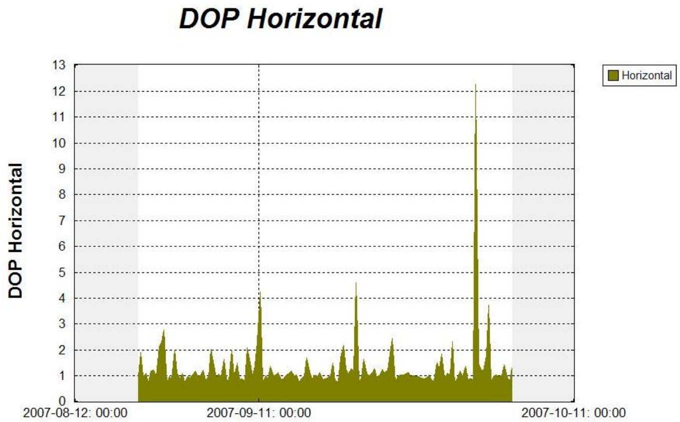

Figure 7. The common HDOP coefficient for the GLONASS and GPS system

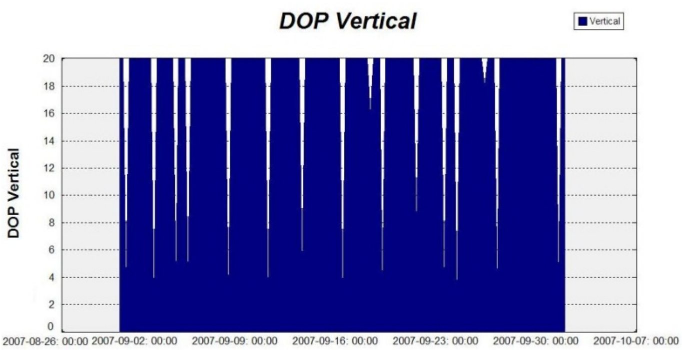

Figure 8. VDOP coefficient for the GLONASS system

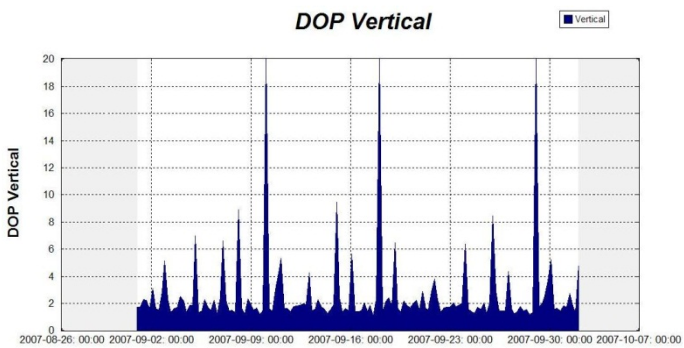

Figure 9. VDOP coefficient for the GLONASS system

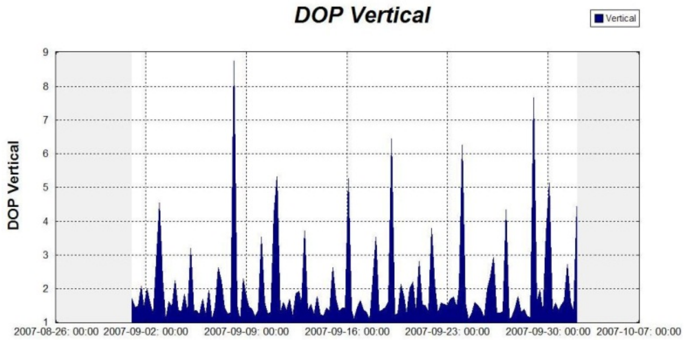

Figure 10. The common VDOP coefficient for both systems

5 PDOP (PRECISION COEFFICIENT FOR DETERMINATION OF 3D POSITION)

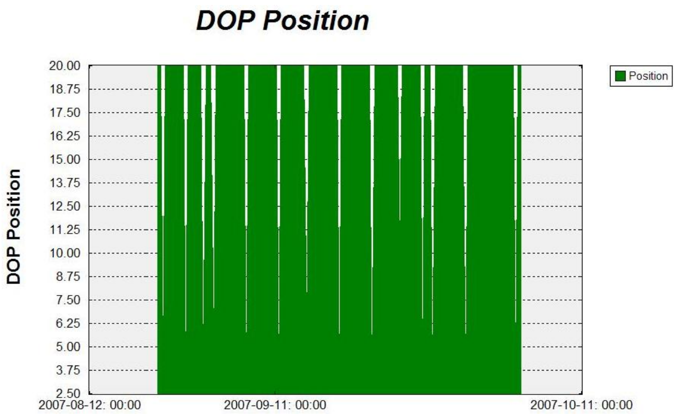

Figure 11. PDOP coefficient for the GLONASS system

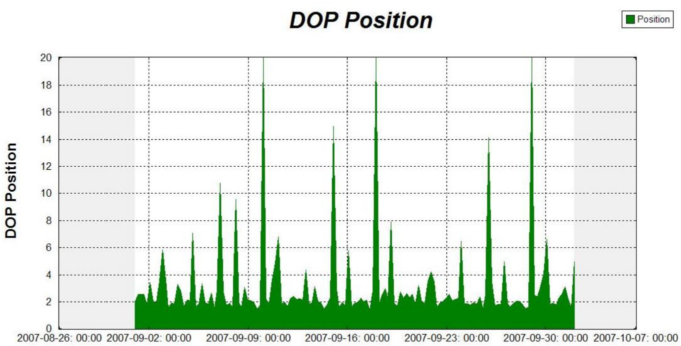

Figure 12. PDOP coefficient for the GPS system

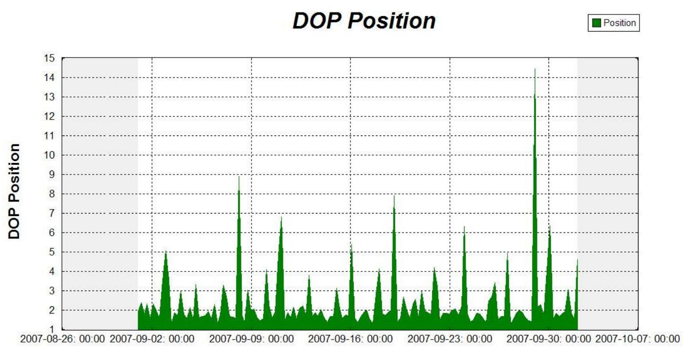

Figure 13. The common PDOP coefficient for both systems

6 TDOP (TIME DILUTION OF PRECISION)

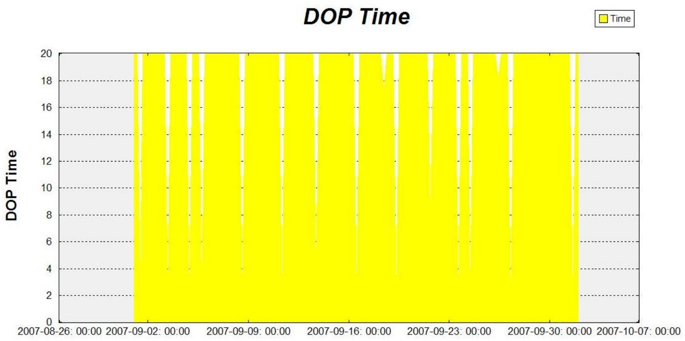

Figure 14. TDOP coefficient for the GLONASS system

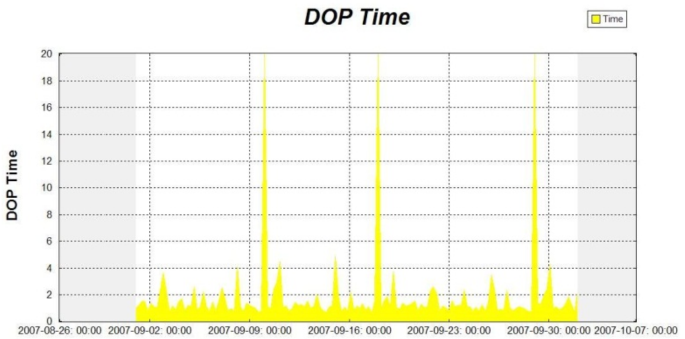

Figure 15. TDOP coefficient for the GPS system

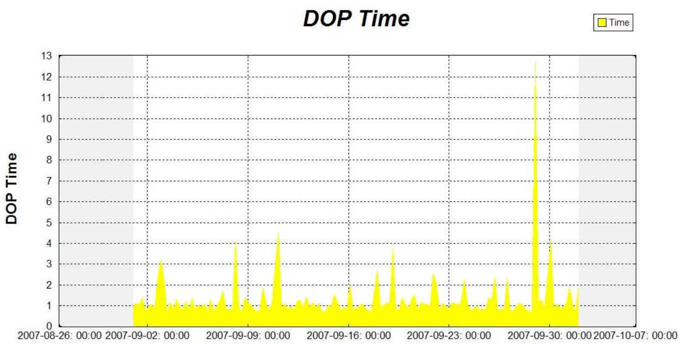

Figure no. 16. The common TDOP coefficient for both systems

7 DOP ANALYSIS SUMMARY

All DOP graphs are strongly correlated – firstly with the number of observed satellites, and secondly with their placement in the horizontal hemisphere. They confirm that 3D or even 2D positioning using only GLONASS satellites is, in practice, senseless. This is confirmed by the sample Figure no. 16 which presents the number of GLONASS satellites visible over a twenty-four hour period in the vicinity of Warsaw.

In practice, the use of the GLONASS system in addition to the GPS system gives very poor results. The DOP coefficients fall insignificantly, which has no major impact on accuracy achieved. The GPS system provides DOP coefficients of a value below three for the decided bulk of the time.

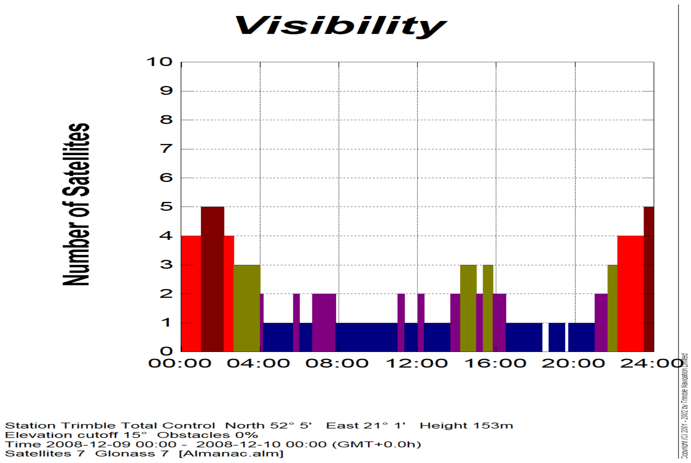

Figure 16. GLONASS satellite visibility in Warsaw

The only situation in which the Russian satellites might have a major impact on accuracy would be a situation in which the GPS satellite was low over the horizon, while the GLONASS satellites would be high. The measurement would be improved in such a case. However, analysis of almanacs for GPS shows that such situations are very rare and their duration is very short.

8 CONCLUSIONS

The objective of this experiment was to compare position determination in the GPS and GLONASS systems as well as applying combined solutions. It was demonstrated that:

– As of today, it is difficult to speak of the determination of position exclusively on the basis of GLONASS satellites.
– The past year has seen the replacement of old type satellites with new ones – GLONASS-M – rather than expansion of the space sector as stated by *Inside GNSS* (the number of active satellites has not changed over the year).
– If one is to believe the promises of the Prime Minister of Russia (dated from before the crisis), one can have hopes that by the end of 2009 the system will be expanded to an operational state. However, nothing seems to support this premise.
– The compensatory effect of the two systems (albeit it is difficult to unequivocally state if this is not temporary) may be considered a promising premise for the future, when the number of GLONASS satellites approaches an operational level.